MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXXIX. FEBRUARY 14, 1919. No. 4

ANNUAL GENERAL MEETING.

Major P. A. MACMAHON, D.Sc., Sc.D., LL.D., F.R.S., PRESIDENT, in the Chair.

The President, referring to the death of Professor E. C. Pickering, said:—

"The Fellows of the Society have heard with deep sorrow and with much emotion of the death of Edward Charles Pickering, the Director of the Harvard College Observatory. It has made a terrible gap in the ranks of astronomers—how great it is not possible to say at the present moment, but it is certain that he was a foremost champion of astronomical science. I feel that I can assume that the Fellows will approve a resolution which I will propose from the Chair: 'That the Society send a message of sympathy and condolence to his relatives and many friends, and also to that considerable band of astronomers whose energies he directed and controlled with such consummate skill.' I invite you to pass the resolution by resuming your seats in silence."

The resolution was adopted in silence.

The Report of the Auditors of the Treasurer's accounts for the year 1918 was read, and is given on p. 224.

The Address was delivered by the President, after which the Gold Medal was handed to the Comte de Ribes, Attaché of the French Embassy, for transmission to M. Guillaume Bigourdan, to whom it had been awarded for his Observations of Nebulæ, carried on for about twenty-five years.

The Annual Report of the Council was partly read.

It was proposed and carried that the Report of the Council be received and adopted, and that it be printed and circulated in the usual manner, together with the President's Address and the Report of the Auditors.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 315.

The thanks of the Meeting were given to the retiring Officers and other Members of the Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

Theralandoor Panchapagesa Bhaskara Shastri, M.A., Assistant, Nizamiah Observatory, Hyderabad, Deccan, India;

Miss Agnes Fry, Failand House, Failand, near Bristol;

Henry Bedingfield Goodwin, Retired Naval Instructor, Royal Navy, 153 Norbury Crescent, Norbury, S.W. 16;

Clarence Victor Grant, B.A. (Cantab.), Kirmington, Brocklesby, Lincolnshire;

Horace Lamb, M.A., Sc.D., D.Sc., LL.D., F.R.S., Professor of Mathematics in the University of Manchester, 6 Wilbraham Road, Fallowfield, Manchester;

William Percy Dartrey MacMahon, 78 Britannia Road, Southsea, Hants;

Sidney Batt Mattey, B.Sc., R.E., 32 Heavitree Road, Plumstead, S.E. 18;

George Frederick Simpson, B.A., Captain R.G.A., Daneholm, Alexandra Park, Manchester;

Walter Robert Stokes, 53 Finsbury Park Road, London, N. 4; and

James Watt, Writer to the Signet, 24 Rothesay Terrace, Edinburgh,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Denis Arthur Casey, D.Sc., Lieut. R.N.R., Spring Gardens, Channel Islands (proposed by Capt. J. M. Harvey);

Capt. Henry Percy Douglas, C.M.G., R.N., Assistant Hydrographer, Admiralty, Whitehall, S.W. 1 (proposed by H. F. Newall);

Henry Reginald Fry, B.A. (Cantab.), Hadley Hurst, Barnet (proposed by H. H. Furner);

William Thomas Gayfer, Schoolmaster, Rose Villa, Frederick Street, Cleethorpes (proposed by Charles Lewis Brook);

Commander George Robinson Hudson, R.D., R.N.R., D.T.O., of the Staff, Royal Naval Barracks, Portsmouth; and 14 Merton Road, Southsea, Hants (proposed by Edward Hawkins);

Henry Francis Jackson, Captain, R.A.F., Member of the Royal Aeronautical Society and of the Society of Engineers, Rugby Hotel, Euston Grove, N.W. 1 (proposed by E. W. Barlow);

Prafulla Chandra Jotirbhusan, Professor of Astronomy, Free Sanscrit College, 2 Ramanath Mazundar Street, Calcutta (proposed by Professor Umes Chandra Ghosh);

Harold Pain, M.A., Clerk in Holy Orders, St. Andrew's Vicarage, Eastbourne (proposed by E. Nevill);

Edward Prentice, St. Mary's Lodge, Ashtead, Surrey (proposed by the Rev. Theodore E. R. Phillips);

Sir William Napier Shaw, F.R.S., 10 Moreton Gardens, London, S.W. 5 (proposed by H. F. Newall);

George Neville Watson, M.A., Sc.D., Professor of Mathematics in the University of Birmingham, The University, Edmund Street, Birmingham (proposed by J. W. Nicholson); and

James Bruce Williamson, Middlesex Hospital, London, W. 1 (proposed by S. Chapman).

Report of the Council to the Ninety-ninth Annual General Meeting of the Society.

The following table shows the progress and present state of the Society:—

	Patron	Honorary Member	Fellows		Associates	Total
			Compounders	Annual Subscribers		
1917 December 31	1	1	226	462	50	740
Since elected	...	...	+1	+29	+3	...
Deceased	...	...	−5	−8	−1	...
Resigned	...	...	...	−6	...	...
Since compounded	...	...	+2	−2	...	...
Removed from list	...	...	...	−10	...	...
1918 December 31	1	1	224	465	52	743

(Six Associates are also Fellows, and are therefore counted twice in the above table.)

Mr. Knobel's Account as Treasurer of the Royal

RECEIVED.

	£ s. d.	£ s. d.
Balances, 1917 December 31 :—		
In hand of Assistant Secretary on Petty Cash Account	0 11 11	
In hand of Assistant Secretary on account of Turnor and Horrox Fund	8 14 6	
		9 6 5
Received on account of Dividends :—		
£1,250 Metropolitan 3-per-cent. Stock ...	26 14 6	
£2,000 Swansea Corporation 3½-per-cent. Stock	50 15 0	
£3,500 East Indian Railway 3-per-cent. Debenture Stock	74 16 3	
£3,500 London and North-Western Railway 3-per-cent. Debenture Stock	77 8 9	
£4,000 Midland Railway 2½-per-cent. Debenture Stock	73 15 0	
£1,000 Lancashire and Yorkshire Railway 3-per-cent. Preference Stock	21 18 9	
£2,400 Gas Light and Coke Co. 3-per-cent. Debenture Stock	53 2 0	
£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock	42 17 6	
£1,552, 12s. 6d. War Loan 5-per-cent. Stock...	77 12 6	
		499 0 3
Received on account of Subscriptions :—		
Arrears	180 12 0	
Annual Contributions for 1918	684 8 0	
,, ,, in advance	6 6 0	
Admission Fees	56 14 0	
First Contributions	39 18 0	
		967 18 0
Compositions		68 5 0
Sales of Publications :—		
At Society's Rooms	21 2 6	
At W. Wesley & Sons' £118 11 1		
Less 10 per cent. discount 11 17 1		
	106 14 0	
Herschel's Works: half share, received from the Royal Society	5 0 0	
		132 16 6
Sales of Photographs		24 17 9
London Mathematical Society, for use of Rooms ...		20 0 0
Income Tax refunded by Commissioners of Inland Revenue		144 17 4
Proceeds of sale of £200 5-per-cent. War Loan Stock		188 14 0
Cheques outstanding, 1918 January 1		12 10 3
Cheque outstanding, 1918 December 31		13 13 0
Excess on Cheque and French Money Order ...		0 0 11

Examined and found correct.

(Signed) W. B. GIBBS.
H. P. HOLLIS.
D. BAXANDALL.

1919 *January.*

£2,081 19 5

Astronomical Society, from 1918 *January* 1 *to December* 31.

PAID.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
" " Editing Society's Publications	50	0	0			
Clerk: Salary £100 0 0						
Less Army pay 65 18 9						
	34	1	3			
Assistant Clerk: Salary	109	4	0			
Porter and wife: Wages	122	5	0			
				565	10	3
House Duty	2	12	6			
Fire Insurance	10	13	0			
Aircraft Insurance	4	10	0			
Insurance of Stock at printers'	2	14	0			
Servants' Insurance Stamps	1	6	0			
				21	15	6
Printing, etc.:—						
Monthly Notices	496	14	6			
Memoirs	121	0	6			
List of Fellows and Miscellaneous	27	9	2			
Photo-engraving	16	2	9			
				661	6	11
Reproduction of Photographs for sale				27	11	3
Turnor and Horrox Fund: Purchase of Books for Library				13	0	1
Expenses of Meetings	17	12	2			
Time Signal: Rental of Wire	5	0	0			
				22	12	2
Telephone Subscription	6	10	0			
Registration of Telegraphic Address	1	1	0			
Postage, etc. (including postage of Monthly Notices and Memoirs)	90	18	5			
Carriage of Parcels	1	5	7			
Stationery and Office expenses	15	16	11			
				115	11	11
House expenses	12	7	0			
Coal, Gas, and Electric Light	83	1	6			
Sundry fittings and repairs	12	5	4			
Sundries	5	0	2			
				112	14	0
Insurance of Gold Medal				1	6	0
Subscription to Board of Scientific Societies ...				20	0	0
Expenses of Meetings of London Mathematical Society				5	2	2
Lee and Janson Fund Grants				12	0	0
Hannah Jackson (*née* Gwilt) Gift				25	0	0
Stamps for cheque-book and Bankers' charges on cheques				0	11	6
Deficiency on French Money Orders				0	0	7
Interest on overdraft at Bankers'				0	10	10
Cheques outstanding, 1918 January 1				25	8	6
Cheques outstanding, 1918 December 31				17	3	6
Debit balance, 1918 January 1				227	0	11
Balances, 1918 December 31:—						
At Bankers', as per Pass-book	205	3	3			
In hand of Assist. Sec. on Petty Cash Account	1	15	8			
" " on Account of Turnor and Horrox Fund ...	0	14	5			
				207	13	4
				£2,081	19	5

Report of the Auditors.

We have examined the Treasurer's accounts of receipts and expenditure for the year 1918, and have found and certified the same to be correct. The cash in hand on 1918 December 31, including the balance at the bank, etc., amounted to £207, 13*s.* 4*d.*

The funded property of the Society has been reduced by the sale of £200 5-per-cent. War Loan Stock.

The books, instruments, and other effects appear to be in a satisfactory condition. An 8½-inch equatorial reflecting telescope, with star spectroscope, has been presented to the Society by the widow of the late Mr. T. E. Heath.

A list has been laid on the table of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

The certificates of railway and other stocks have been examined, and the stocks inscribed at the Bank of England verified.

(Signed) W. B. Gibbs.
H. P. Hollis.
D. Baxandall.

1919 *January* 7.

Gifts to the General Funds of the Society.

In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2,000 Consols.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2,000, free of legacy duty.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

Trust Funds.

The Lee and Janson Fund: In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334, 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock.

	£	*s.*	*d.*		£	*s.*	*d.*
1918 Jan. 1. Balance of Fund	43	1	7	1918. Grants from Fund	12	0	0
1918. Dividends, East Indian Railway ...	10	0	9	1918 Dec. 31. Balance of Fund	41	2	4
	£53	2	4		£53	2	4

The Turnor Fund and the Horrox Memorial Fund: In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464, 18*s.* East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38, 15*s.*, the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrox: to this the Society added the sum of £55, 15*s.*, and the whole now stands in £103, 6*s.* East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the Library.

	£	*s.*	*d.*		£	*s.*	*d.*
1918 Jan. 1. Balance of Fund	5	15	2	1918. Purchase of Books	13	0	1
1918. Dividends, East Indian Railway ...	17	1	0	1918 Dec. 31. Balance of Fund	9	16	1
	£22	16	2		£22	16	2

The Hannah Jackson (née Gwilt) Fund: In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309, 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£	*s.*	*d.*		£	*s.*	*d.*
1918 Jan. 1. Balance of Fund	53	14	5	1918 Feb. 8. Gift ...	25	0	0
1918. Dividends, East Indian Railway ...	9	6	0	1918 Dec. 31. Balance of Fund	38	0	5
	£63	0	5		£63	0	5

Assets and Present Property of the Society, 1919 January 1.

	£	s.	d.	£	s.	d.
Balances, 1918 December 31 :—						
At Bankers', as per Pass-book	205	3	3			
In hand of Assistant Secretary on Petty Cash Account	1	15	8			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	0	14	5			
				207	13	4
Due on account of Subscriptions :—						
3 Contributions of 4 years' standing	25	4	0			
10 ,, 3 ,, ,, ...	63	0	0			
36 ,, 2 ,, ,, ...	151	4	0			
64 ,, 1 ,, ,, ...	134	8	0			
Other sums	15	3	0			
	388	19	0			
Less Contributions paid in advance	6	6	0			
				382	13	0
Due for Photographs sold				1	4	0
Due from Wm. Wesley & Son for sales of Publications during the last quarter of 1918				11	13	9

£1,250 Metropolitan 3-per-cent. Stock.

£2,000 Swansea Corporation 3½-per-cent. Stock.

£3,500 East Indian Railway 3-per-cent. Debenture Stock.

£3,500 London and North-Western Railway 3-per-cent. Debenture Stock.

£4,000 Midland Railway 2½-per-cent. Debenture Stock.

£1,000 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.

£2,400 Gas Light and Coke Co. 3-per-cent. Debenture Stock.

£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock.

£1,352 12s. 6d. War Loan 5-per-cent. Stock.

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, etc.

Stock of Publications and Photographs.

Three Gold Medals.

Celestial Photographs.

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to the Fellows :—

R.A.S. Ref. No.

277–282. Solar prominence 1916 May 26 (showing development of prominence), J. Evershed.
283. Spectroheliogram, K, 1917 August 10, J. Evershed.
284. Spectroheliogram, Hα, J. Evershed.

The Award of the Gold Medal.

The Council have awarded the Society's Gold Medal to M. Guillaume Bigourdan for his observations of Nebulæ, carried on for about twenty-five years. The President will lay before the Society the grounds upon which the award has been founded.

Publications of the Society.

During the past year vol. lxxviii. of the *Monthly Notices* has been published.

The following part of the *Memoirs* has also been published :—

Vol. lxii. part 3, W. M. Smart, "Libration of the Trojan Planets: Paper 1."

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associate during the past year :—

Fellows :—Rev. Edward Aurelius Adams.
George Beaver Croucher.
Thomas Edward Heath.
Frederick John Horne.
Rev. Peter David Morse.*
Robert John Pocock.
George Mitchell Seabroke.
Beauchamp Prideaux Selby.
Peter Thompson.
John David Walther.
Henry Addenbrook Wassell.
Harry J. Watson.
George Joseph Weldrick.*
Associate :—Charles Joseph Etienne Wolf.

Edward Aurelius Adams was born on 1836 December 2, at Newton Blossomville, Bucks ; he entered Caius College, Cambridge, in 1856, where he won a scholarship. He graduated in 1860 as a Senior Optime, and was ordained in the same year at Ely. He was curate of St. Mary's, Bury St. Edmunds, from 1860–62 ; curate of Holy Trinity Church, Marylebone, 1862–69. He was appointed the first Vicar of the new church of St. John the Evangelist, Meads, Eastbourne, in 1869. He resigned his charge in 1892 and settled at Hove, where he died on 1918 September 7.

He married in 1866 Alice, daughter of Sir R. Carden. She died in 1891.

He was elected a Fellow of the Society on 1883 March 9.†

George Beaver Croucher was born at Greenwich in 1881. He joined the Navy in 1896, and served under the command of the late Captain Scott in his first Antarctic Expedition, 1901–1905. On his return he married, and led a shore life for a time. At the outbreak of war he was Principal of the Grimsby Navigation School, and Technical School for Fishermen. In 1916 August he rejoined the Navy, obtaining the rank of Lieutenant. He was placed in command of H.M.S. *Stoic*, and succeeded in saving a Norwegian ship which had been torpedoed by a submarine. He was afterwards invalided home for three months ; on his recovery he was

* Deaths not reported till 1918.

† There is an erratum in the recent Lists of Fellows (since 1915), which give the date of his election as 1905 January 13, that date actually applying to Alexander John Samuel Adams.

sent to the Naval Transports at Cardiff, where he remained till his death, which took place on 1918 April 16.

He has left a widow, two daughters, and a son.

He was elected a Fellow of the Society on 1915 January 8, and was also a Fellow of the Geographical Society.

Thomas Edward Heath was born in 1849, being the eldest son of Mr. Thomas Edward Heath, J.P., of Northlands, Cardiff.

His father had founded the works of the Star Patent Fuel Co., Cardiff, in the early days of the coal trade; after his death Mr. Heath, with his brothers Ivor and Ernest, carried on the business as joint managers. He had an extensive knowledge of engineering, and made several inventions of machinery for the manufacture of patent fuel. He had in addition a great zeal for science, and particularly astronomy; his mechanical bent showed itself in a paper that he contributed to *M.N.*, **67**, 527, on "An Equatorial Driven by a Hydraulic Ram." But the main aim of his astronomical writings was to spread a knowledge of the actual arrangement of the stars in space, and their relative magnitudes. He exhibited some ingenious stereoscopic charts at a meeting of the Society, in which the stars were thrown into relief when viewed through red and green spectacles, which were provided. His *Road-Book to the Stars* and *Tracks of the Sun and Stars in Space of Three Dimensions* make use of the relation that on the scale of an inch to an astronomical unit a light year is almost exactly one mile. Shortly before his death he published a very useful work, *The Distances, Absolute Magnitudes, and Spectra of 734 Stars*, which was sold for the benefit of the Tenby War Emergency Depot. He acknowledged his indebtedness to the similar publication of Rev. O. R. Walkey (*J.B.A.A.*, **27**), but he added 109 more stars, many new parallax determinations, and arranged the tables in a manner that made it easier to realise the true configuration of the stars in space. He appended to the volume some "Reveries," which show poetic skill and a deep reverence for the wonders of creation. He had also some artistic ability.

For the last five years he lived at Tenby, where he died on 1918 January 3.

He married in 1876 the daughter of the late R. H. H. Victor, who survives him with two daughters.

Mrs. Heath presented to the Society the 8½-inch reflecting telescope belonging to her husband, together with a number of his stereoscopic charts.

He was elected a Fellow of the Society on 1906 March 9.

Peter David Morse was born at Llani Cant, Pembrokeshire, in 1863. He studied at Trevecca for the Welsh Calvinistic Methodist ministry, and was ordained about the year 1892. He was pastor at Pendive in Carmarthenshire for some time, but retired early to Llani Cant, where he lived in seclusion, pursuing

his studies, and preaching every Sunday in the churches of his denomination.

He took a very active part in temperance movements in South Wales, and was for some time Secretary to the General Assembly of the Welsh Methodist body. He was a keen musician, and held diplomas from the Tonic Sol-Fa College.

He was unmarried. He died at Llani Cant from heart failure on 1917 June 12.

He was elected a Fellow of the Society on 1916 March 10.

Robert John Pocock was born at Harlesden, N.W., on 1889 January 23, and was educated at Christ's Hospital and Queen's College, Oxford, of which he was a scholar. He showed marked ability at school; gained first classes both in mathematical Moderations and Finals (1912) at Oxford, and the Senior Mathematical Scholarship, and after a year's work at the University Observatory obtained a B.Sc. research degree for an investigation of the method of superposing several regions of the sky on the same plate. In 1915 he was awarded the Manuel Johnson prize for two essays, one upon the distribution of stars, and another on a case in the restricted problem of three bodies. Early in 1914 he was appointed to succeed Mr. A. B. Chatwood as Director of the Nizamiah Observatory, Hyderabad. Mr. Chatwood had seen to the building of an observatory and the erection of the telescope, but serious work on the astrographic zones allotted to the observatory in 1909 (viz. $-17°$, $-18°$, $-19°$, and $-20°$, the northern half of the zone originally assigned to Santiago) had not yet been commenced, and the telescope had been sent to England for repair. Coming straight from Oxford in 1914 March, Mr. Pocock naturally found his Indian surroundings and work very strange, especially when war broke out soon afterwards. Moreover, later in the year he had a severe attack of malarial fever. Nevertheless he faced the situation so courageously and efficiently that he had advanced far towards the completion of the work at the time of his sudden death from pneumonia following on influenza. Zone $-17°$ was published, zone $-18°$ completely printed (so that the volume has since been issued); in zone $-19°$, 159 plates had been completely measured, and in zone $-20°$, 101 plates; while all the preliminary reductions had been made, and part of zone $-19°$ was already printed. And all this in specially trying conditions, which included the loss of twenty-four dozen anxiously awaited plates in the *Persia*, the loss of MSS. and printed sheets of the first volume through a disastrous fire at the printers' (Messrs. Neill & Co.), the frequent failure of plates in sensitiveness owing to war shortages, and latterly the frequent interruption of his own work for military drill, which his not very powerful physique found unusually trying. Having regard to all these drawbacks, it may safely be said that under normal conditions he would have finished the allotted work in the five years for which he was appointed, and even as it stands his achievement, which a very small extension of

his lease of life would have rendered complete, bears comparison with anything that has been elsewhere accomplished in this direction.

He by no means limited himself to the mere routine work, but was prompt in collecting and discussing the results, as sixteen short papers in the *Monthly Notices* amply testify.

His physical frame was, as already remarked, not vigorous, but he showed certain powers of endurance in "hare and hounds"—possibly the same endurance which enabled him to achieve so much in the observatory. He was also fond of geology, chess, and stamp collecting. He married Mrs. Lyons in Bangalore in 1915, who is left with two baby daughters, one born ten days after the father's death. The Nizam has granted her a pension of £100 a year, and she contemplates returning to England.

Mr. Pocock was elected a Fellow of the Society 1914 February 13. He died on October 9 last.

George Mitchell Seabroke was born on 1838 April 1, and was educated at Rugby, but left school in order to enter a solicitor's office before he reached the Sixth Form. But he remained connected with Rugby School all his life, acting as honorary curator of the "Temple" Observatory, teaching practical astronomy, and training successive generations of schoolboys to the use of the instruments. It was while young Seabroke was still at the school that his House and Science Master, the Rev. J. M. Wilson, now Canon of Worcester, interested him in astronomy, and after he had left the school Dr. Wilson placed at his disposal a small telescope mounted in his garden. Seabroke soon set to work to make a reflector for himself, devising and constructing the grinding and polishing machine together with a small engine to work it. With these he made two or three mirrors and mounted them. A little later Dr. Wilson secured the famous $8\frac{1}{4}$-inch refractor that Alvan Clark had made for the Rev. W. R. Dawes. This became the chief instrument of the Temple Observatory, and with it Seabroke and Wilson made the series of measures of double stars and spectroscopic observations which were communicated to the Royal Astronomical Society and appeared in the *Monthly Notices* and the *Memoirs* between the years 1873 and 1890. His work at the Temple Observatory was his most important contribution to astronomy from two points of view: here his own direct observations were made, and here he influenced many hundreds of schoolboys, not only giving them interest in the "wonders of the heavens," but training them to the order, method, and accuracy which the pursuit of astronomy develops. The first report of the Temple Observatory, Rugby, appears in the Report of the Council of the R.A.S. to the Fifty-Third Annual General Meeting in 1873 February 14, in these words:—"This is an observatory founded at Rugby in memory of the present Bishop of Exeter, late Headmaster of Rugby School. . . . The observatory is used for educational purposes, and the work of

observing is therefore much interrupted. . . . Drawings of sun-spots, Encke's Comet, Venus, Jupiter, and Mars have been made repeatedly by some of the boys, who also assist in double-star measuring and in some of the calculations." It was in this observatory that he spent the last evening of his life. The attendances of the boys at the observatory seem to have numbered between three and four hundred in the year.

Several of his early papers, communicated to the R.A.S. and dealing with the work of the Temple Observatory, show his thoughtful treatment of the facts of astronomy as then recognised. In the xxxivth volume of the *Monthly Notices*, p. 29, under the title "Remarks on Spectroscopic Observations of the Sun, made at the Temple Observatory, Rugby School, in 1871–2–3," Mr Seabroke, in conjunction with Dr. Wilson, suggests eight points for inquiry to be determined by observation. Of these several have now been more or less settled, but some still await further investigation. Thus we read, No. 5: "Faculæ should have a proper motion in the opposite direction to that of a spot"; No. 6: "A spot should be more frequently bridged from the West, as we see the Sun, than from the East"; No. 8: "The period of spots ought to coincide with that of some assignable cause of disturbance of pressure."

Mr. Seabroke was one of the founders of the British Astronomical Association and an original member of its Council. He served as President, 1900–1902, was Director of the Double-Star Section, 1892–1915, and of the Saturn Section, 1898–1911. His Presidential Address in 1901 dealt with problems of the ether, relativity, and gravitation, which now occupy a considerable place in astronomical thought, but were then just coming into notice.

He also took a considerable part in the civic life of Rugby. He was one of the founders of the National Union of Fire Brigades, and in 1895 he organised for the town a volunteer fire brigade, in the efficiency of which he always took an active interest. He became a member of the Board of Health in 1875, and took a leading part in perfecting the Rugby water-supply. He was an active member of the old Rugby Volunteer Corps for forty years, and on his retirement was given the rank of honorary Lieut.-Col. of the 2nd Royal Warwickshire Volunteer Company. He was appointed Deputy-Lieutenant of the County of Warwickshire a few weeks before his death, which took place suddenly, through heart failure, on 1918 April 1.

Quiet and unassuming in disposition, he never pushed himself forward, but whenever he was asked for the help which his knowledge and sound judgment so often enabled him to give, he was prompt and ready to supply it. His old Master and life-long friend and colleague has thus summed up his character:—"In my long life and fairly wide experience I have known no one more truly scientific in spirit and in aims, more conscientious, truthful, modest, accurate; none of sounder judgment, none more faithful to his friends, or to any cause or work which he took up.

For fifty years I held him in the highest honour and confidence and love."

He was elected a Fellow of the Society 1878 April 8, and served on its Council from 1894 to 1902.

Beauchamp Prideaux Selby was born at Bradley Hall, Northumberland, on 1841 August 23. He was educated at Harrow, and St. John's College, Cambridge. He studied for the Bar, and became a member of Lincoln's Inn, but never practised as a Barrister. For many years he was a zealous member of the Inns of Court Volunteers, and an excellent rifle shot, winning several prizes at the annual meetings of the N.R.A. at Wimbledon.

He resided at Pawston, Northumberland, and became Chairman of the Bench for Northumberland and Islandshire, continuing to attend the Courts till within a few months of his death.

Throughout his life he took much interest in astronomy and geology, though he did not write any papers on these subjects.

He married in 1881 Fanny Pocklington Senhouse, and had two sons: the elder, Beauchamp Henry, became a Captain in the 5th Northumberland Fusiliers, and was killed at the battle of the Aisne in 1914 September; the younger, Prideaux Joseph, enlisted in the Northumberland Fusiliers in 1914 August, immediately after the outbreak of war; he died of fever at Gibraltar on 1915 October.

Mr Selby died at Pawston on 1918 November 6, his estate passing to his nephew.

He was elected a Fellow of the Society on 1897 January 8.

Peter Thompson was born at Liverpool, on 1836 July 13. He adopted a nautical career, and on 1878 July 2 he was admitted and sworn a Younger Brother of the Hon. the Corporation of Trinity House.

Afterwards he held for many years the post of Senior Examiner in Navigation and Seamanship for the Port of London, and Secretary of the Local Marine Board, London.

During this period he wrote several text-books on navigation, the latest being a pamphlet entitled *Navigation Simplified*, published not long before his death. It is unfortunate that, owing doubtless to inadvertence on the part of the author, this pamphlet is so worded as to convey the erroneous impression that both longitude and latitude can be derived from a single observation of a heavenly body.

He died at Bickley, Kent, on 1918 April 13.

He was elected a Fellow of the Society on 1880 June 11.

Henry Addenbrook Wassell was born in 1838 at Oldswinford, Stourbridge, Worcestershire, and remained there all his life, save for a brief period in early manhood spent in study in London. After this he engaged for a time in commerce; but after a few years, finding himself in possession of a modest competency, he

retired from business, and gave a large part of his time to religious work among the Plymouth Brethren, to which body he belonged, also to lecturing and temperance advocacy. But he had also a great love of mechanical and scientific study, and his delicate health encouraged such sedentary pursuits. He wrote an important series of letters on the testing of paraboloidal mirrors to the *English Mechanic*, Nos. 887, 890, 894, 899, 902, 907, 911, 962, 1078, 1089, 1129, the dates ranging from 1882 April to 1886 November. The Rev. C. D. P. Davies, in his paper on the same subject (*M.N.*, **69**, 355), refers to them as "the fullest and best description hitherto published," alluding especially to his admirable device for controlling the size of the illuminating aperture.

Mr. Wassell married a daughter of the late William Willder, Esq., of Gnosall, Staffs, who survives him. There was no issue of the marriage.

He died at Oldswinford on 1918 July 15, being much missed by a large circle of acquaintance, who esteemed him for his large-hearted benevolence, and admired his interesting and logical writings.

He was elected a Fellow of the Society on 1887 June 10.

Harry J. Watson was born at Cossepore, Bengal, on 1850 May 4, being the son of Mr. James Watson of the Indian Civil Service, and grandson of Mr. Wilberforce Bird, Deputy Governor of Bengal. He served for many years in the 11th Hussars, retiring with the rank of Lieut.-Col. in 1890. He settled first at Langley, Bucks, and afterwards at Deramore, Camberley, Surrey.

He was ardently devoted to astronomy, and had an observatory at Camberley equipped with several powerful telescopes; some of them were adapted for lunar and solar photography, which he practised a good deal, being also much interested in the study of Jupiter and Saturn.

He was a frequent correspondent to the *English Mechanic* on astronomical subjects, and attended the meetings of this Society as often as he could. He much regretted that travelling difficulties during the war prevented his more frequent attendance. He was an original member of the British Astronomical Association, and a member of the Société Astronomique de France.

He died at Camberley, after an illness of seventeen days, on 1918 April 5, leaving a widow.

He was elected a Fellow of the Society on 1885 April 10.

George Joseph Weldrick was born at Idrone House, Blackrock, Co. Dublin, on 1883 May 2. He was the second son of John Francis Weldrick, who was a literary editor. He was educated at Blackrock College, and at the age of 16 was indentured apprentice with Messrs. James Cornfoot, London; they placed him on the ship *Black Rock*, which sailed between the Thames and San Francisco. He passed for second mate in 1903, for first mate in 1904, and obtained his Master's certificate in 1907, being

appointed a Master on the Elder, Dempster Line in 1908; he also held a pilot's certificate for Lagos, West Africa. He subsequently served in the White Star and Orient Lines, and was gazetted to the Royal Naval Reserve as sub-Lieutenant in 1911, becoming Lieutenant in 1913. He served on the *Excellent*, *Irresistible*, and *Bellerophon*. On the outbreak of war in 1914 he was posted to H.M.S. *Hannibal*, and transferred to H.M.S. *Clan MacNaughton* in 1914 December. He was lost when that ship was torpedoed on 1915 February 3 while on patrol duty.

He was unmarried. He was a Fellow of the Royal Meteorological Society, and a Member of the Imperial Merchant Service Guild.

He was elected a Fellow of the Society on 1911 January 13.

Charles Joseph Etienne Wolf was born at Vorges, near Laon (Aisne), on 1827 November 9, being a member of a family of eleven, many of whom became known for zealous service in the army or the university. His father, Pierre Frédéric Wolf, who was an Alsatian by birth, was Mayor of Vorges, where he had settled on the day of his marriage.

The young Charles was early distinguished by his zeal for work and his passion for accuracy. Towards the end of his studies he was elected to a scholarship at the Rollin College; he won the prize for Physics at the general examination, and then was for some time a pupil teacher at the same college. In 1848 he was admitted to the Ecole Normale Supérieure, where he had as companions Challemel-Lacour, Adolphe Perraud, Taine, and Prevost-Paradol. After the completion of the course in 1851, he was immediately appointed Professor of Physics at the Lycée of Nîmes, afterwards at that of Metz (1852 September 17): while there he prepared his thesis for the doctor's degree, which he completed successfully (1856 December 10); the subject was the effect of temperature on the phenomena that take place in capillary tubes.

In the following April he was sent to Montpellier as Professor of Physics at the Faculty of Sciences, where he lectured on acoustics and spectrum analysis. Already, it would seem, astronomy attracted him, for he observed in Spain the total solar eclipse of 1860 July 18. A little later, Le Verrier, during a visit to Montpellier, was attracted by the young Professor, and offered him the post of Assistant at the Paris Observatory. It was thus that Charles Wolf was appointed "Astronome titulaire" at the Observatory on 1862 October 10.

He was soon entrusted with the astronomical education of the students, and was in this way drawn towards the improvement of meridian observations. He proceeded to revise the "instructions to observers," which are still followed in their general lines. He undertook his classical researches on the Personal Equation in transit observations, and commenced the studies on the rates of pendulums which culminated in the establishment of the system of synchronisation of clocks that was installed by him, at first in the observatory, and subsequently in the city of Paris. Meanwhile

he was sent in 1867 to the neighbourhood of Naples, to observe the solar eclipse of March 6. He next devoted himself more particularly to equatorial observations. In company with his pupil and friend Rayet, he discovered a new spectral type of stars, with bright lines, which are still known by their joint names. At the same time he commenced his micrometric study of the Pleiades group. The memoir containing his observations has the character of completeness that marks all his work.

He had a profound knowledge of instruments, not only in their mechanical parts, but also in the manner in which they act on light: witness the memoirs on the *Apparences qui accompagnent l'observation des passages de Mercure et de Venus devant le Soleil*, which he wrote in collaboration with Ch. André. While devoting himself to practical astronomy, he did not entirely give up teaching. In 1875, Le Verrier asked him to take his place in the Sorbonne course. Soon afterwards he commenced the Physical Astronomy course, and later he lectured for the Licentiate course, publishing his lectures in the volume *Astronomie et Géodésie* (1891). He had already published his *Hypothèses Cosmogoniques* (1886), a work that led the way to many others, and his *Mémoires sur le Pendule* (1889), which are marked by great erudition. One might mention a number of other works, on photometry, selenography, the invention of new instruments, construction of ecliptic charts, etc.; it is impossible to quote all, but we ought to mention his *Recherches sur les étalons du Système Métrique*, and his *Histoire de l'Observatoire de Paris, 1666 à 1791* (published 1902).

He was elected to the Academy of Sciences on 1883 April 16, and was its President during 1898.

Devotion to truth, to science, to his country, his family and his friends, such was the life of Charles Wolf.

He was by nature distinguished in his person and in his manners, and under a reserved exterior he concealed a warm and faithful heart. He always greeted the young with a kindness of which they preserve a grateful remembrance. He married during his sojourn at Metz; becoming a widower at an early age, he devoted all his affection to his only daughter, who faithfully repaid it up to the end of his life. Subsequently he had the pleasure of seeing his grandchildren growing up, and during the last ten years his great-grandchildren. He kept the paternal mansion at Vorges, where all might be reunited, but during the invasion of 1914 he was obliged to withdraw, and had not the consolation of ending his days there.

Deeply religious, he never either concealed or advertised his sentiments. If he had preferences, he never let them interfere with strict justice. As a savant it can be said of him that he served science by his devotion, and honoured it by his character.

At the age of upwards of ninety he preserved all his faculties. He died at Saint Servan (Ile et Vilaine) on 1918 July 4.

He was elected an Associate of the Society on 1874 January 9.

[The Council are indebted for the above notice to M. G. Bigourdan.]

Proceedings of Observatories.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.
(*Director, Sir F. W. Dyson, Astronomer Royal.*)

During practically the whole year the activities of the observatory have been limited, as explained in previous reports, to the maintenance of continuous series of observations. With the gradual demobilisation and return of those members of the staff who have been absent on military or other war service, the observatory will be able to return to its pre-war activity.

Transit-Circle.—During the year 1918, 3062 transits were observed. The sun was observed on 147 days and the moon on 107 days. Venus and Mercury were regularly observed, but fewer observations than usual were made of the exterior planets. The majority of the transits observed were of clock-stars, the smallness of the available staff permitting very few observations of stars for the Catalogue to be made.

The Catalogue of Stars for 1910 (Dec. $+24^\circ$ to $+32^\circ$) is ready for press, but the printing is still delayed on account of pressure of work at the Stationery Office in connection with demobilisation. A discussion of the solar motion based upon spectral types derived from the results of the new Draper Catalogue, which were sent in advance by Professor E. C. Pickering and Miss Cannon, has been communicated to the Society. The planetary results for 1917 have been completed.

Altazimuth.—The use of this instrument has been restricted to supplementing the observations of the moon made with the transit-circle. The moon was observed 27 times in the meridian and 6 times out of the meridian. The mean correction in right ascension required by the *Nautical Almanac* is $+0^s{\cdot}92$, and by the *Connaissance des Temps* (depending on the revised tables of Delaunay) is $+0^s{\cdot}28$. These quantities are practically identical with those for 1916 and 1917.

Cookson Floating Telescope.—The results obtained with this telescope from 1911 to 1918 are under discussion for the purpose of determining the aberration constant and definitive values of the variation of latitude at Greenwich during that period. Preliminary values of the latter have been communicated to the Society.

During the year, 222 plates for aberration and latitude were obtained and 4 plates for the determination of scale. The measurement of these plates has been completed.

The use of the telescope for the determination of latitude variation is being continued.

Occultations.—Seven disappearances and 3 reappearances were observed during the year. The results have been communicated to the Society.

28-inch Refractor.—126 double stars were measured by M. Jonckheere. These were mostly selected pairs from his Catalogue in *Mem. R.A.S.*, 61. A special study was made of Sirius, which was observed on 13 nights.

In addition to the double-star observations, M. Jonckheere also observed Neptune's satellite and Nova Aquilæ. He followed Encke's Comet, and rediscovered Wolf's periodical comet on 1918 July 9.

Thompson Equatorial.—The object-glass of the 26-inch refractor which had been dismounted on 1917 September 26 was replaced on 1918 October 15. After a number of experimental plates for adjustments and focus had been made, the photography of the larger satellites of Jupiter for Dr. de Sitter was resumed. Eighteen photographs were obtained on 10 nights between October 22 and December 31.

A few photographs of the Pleiades and of the Orion nebula were taken with the 30-inch reflector for comparison with older photographs. Minor planet 887 Alinda was also photographed on 2 nights.

The Astrographic Equatorial.—The photography with this instrument during the year has been almost entirely confined to the new star in Aquila. Photographs of the nova and comparison stars were taken on 50 nights between June 9 and November 7, the results of the measurement of which have been communicated to the Society. Photographs of 12 fields in the astrographic zone have been taken to complete the work of determination of proper motions by direct comparison of plates. In addition, 9 photographs have been obtained of the field in the vicinity of the sun at the eclipse of 1919 May 28, to observe which Dr. Crommelin and Mr. Davidson are being sent from the Royal Observatory under the auspices of the Joint Permanent Eclipse Committee.

In continuation of the work described in previous years, 69 pairs of plates have been compared during the year, and the apparent proper motions derived have been compared with the proper motions determined by comparison of catalogues.

Photoheliograph.—Photographs of the sun were obtained with this instrument on 222 days during the year 1918, of which about 20 were days of poor definition. At the Cape Observatory photographs were obtained on no fewer than 337 days during the year 1918, leaving 10 days unrepresented by satisfactory photographs from the combined record of the two observatories. Of these 10 days 6 are represented in the series taken at Kodaikánal.

No photographs have been received from any of the three collaborating observatories of later date than the end of 1917 February, in consequence of the restrictions on transport imposed by the war; and the measurement of the photographs, partly on this account and partly on account of the smallness of the staff, has only been carried as far as 1917 January 13, the date of the end of the last rotation commencing in 1916.

All the measures have been entered and fully reduced up to the above date, and the complete copy for press written, but the reductions for 1916 have not been fully examined in detail.

In default of micrometric measurement and full reduction, all that it has been possible to do with the incomplete record for 1917 and 1918 yet to hand has been to make a preliminary inspection. From this it would appear that there was a great increase in the spotted area of the sun in 1917 over that for 1916, but that in 1918 the spot-area, though greater than in 1916, fell below that for 1917. Yet it is not clear that the time of maximum activity has been passed, for the mean distance from the equator of all spots is judged to be still about that characteristic of the solar maximum, viz. 14° to 13°, and there has certainly been no long-continued indication of a predominance in sun-spot area of the southern hemisphere over the northern, such as has been witnessed during recent cycles, when the period of decline has definitely set in.

Printing.—The printing of the Greenwich Observations for 1914 has been completed. The printing of the Observations for subsequent years has been suspended for the present.

Personal.—Throughout the greater part of the year the staff at the observatory has remained very small. Mr. Jones left the Inspection Department of the Woolwich Arsenal in December and resumed his duties. It is hoped that other members of the staff will be returning shortly

Mr. Chapman remained as Chief Assistant in an honorary capacity till December 15. His services, at a time when the observatory was very short-handed, have been of great value. The observatory has been specially fortunate in having him to discuss its long series of magnetic observations in conjunction with those made elsewhere. The voluntary assistance of Mrs. Maunder in the Solar Department throughout the year has been much appreciated, and has prevented the accumulation of heavy arrears of measurement and computation at a time of great solar activity. M. Jonckheere returned to Lille early in 1919. During his four years at Greenwich he has made full use of the 28-inch equatorial. The results of his observations are all published in the *Memoirs* of the Society or in the *Astronomical Journal*. It has been a matter of great satisfaction to have the 28-inch telescope so well employed throughout the war.

Royal Observatory, Cape of Good Hope.
(Director, Mr. S. S. Hough, H.M. Astronomer.)

Transit-Circles.—The meridian programme of the previous year, which was devoted to the observations of a series of close circumpolar stars for the purpose of a new determination of the constant of aberration, was brought to a close at the end of 1918 January.

During the months of February and March observations were restricted to occasional time determinations, but regular observing was resumed at the beginning of April on a list of stars selected from Boss's Preliminary General Catalogue.

The observations during the year comprise :—

Observations of Right Ascension :—	
Meridian transits	5391
Determinations of collimation by collimators	95
,, ,, level	266
,, ,, azimuth	133
Observations of meridian marks . . .	638
Observations of Zenith Distance :—	
Determinations of Zenith Distances . .	5174
,, ,, runs	267
,, ,, nadir	245
,, ,, flexure	60

Heliometer.—Observations of the major planets at the time of opposition have been continued with this instrument, and the following have been secured :—

Opposition of Neptune .	36 obs. in distance		on 6 nights.
,, ,, Saturn .	30 ,, ,, ,,		on 5 ,,
,, ,, Mars . .	26 ,, ,, ,,	}	on 5 ,,
,, ,, ,, . .	16 ,, ,, position-angle		
,, ,, Uranus .	48 ,, ,, distance		on 6 ,,
,, ,, Jupiter* (1919) .	6 ,, ,, ,,		on 1 night.

Victoria Telescope and Astrophysical Laboratory.—The telescope and four-prism spectrograph with short camera have been in use on 176 nights during the year, and 246 spectrograms have been secured, chiefly for the determination of stellar radial velocities. 61 of the above plates were devoted to the spectrum of the new star in Aquila between June 10 and November 9, and in addition 18 plates were taken of this object with a rapid short-focus Tessar lens—in most cases with an object-glass prism attached—mounted on the 6-inch telescope, between June 9 and November 5.

* Still under observation 1919 January.

The following papers by Dr. Lunt have been sent for publication :—

(*a*) To the *Astrophysical Journal* :
(1) On the orbit of the spectroscopic binary α Phœnicis.
(2) Alpha Centauri as a spectroscopic binary.
(3) The radial velocities of 119 stars observed at the Cape.
(4) The radial velocities of 185 stars observed at the Cape.

(*b*) To the Royal Astronomical Society :
(5) The dark-line spectrum of Nova Geminorum No. 2.
(6) The spectra of Nova Aquilæ No. 3. I. The dark-line spectrum.

The Astrographic Telescope.—116 repetition "chart" plates for proper motion were taken by Mr. Wood of the Union Government Observatory during the months of March and April. These plates, together with the original chart plates of the same areas, were taken by him to Johannesburg for comparison in the "blink" microscope of that observatory. In addition, the following miscellaneous plates have been obtained :—

	No. of Plates.	
Pleiades (for stellar magnitudes) .	8	(62 exposures)
Saturn	2	(4 „)
Nova Aquilæ	1	(2 „)
Comet Reid, 1918 . . .	13	(13 „)

Photoheliograph.—Daily photographs of the sun to supplement the Greenwich series have been continued throughout the year. In all 698 negatives, distributed on 338 days, have been secured. On account of transport restrictions, these negatives have been retained at the Cape for the present.

Occultations.—Ten separate phenomena of occultations of stars by the moon have been observed during the year, viz. :—

Disappearances at dark limb	5
Reappearances „ „ „	5

The reductions of the observations of all occultations have been completed and prepared for press to 1918 November 11.

Variable Stars.—The 6-inch, and occasionally the 7-inch, equatorials have been placed at the disposal of Messrs. Long and Skjellerup for a programme of observations of Southern variable stars.

Some 98 stars have been under observation, and 1208 determinations of magnitude in all have been secured.

Current Reductions.—All meridian observations up to 1918 December 20 have been reduced so as to exhibit apparent places. The reductions to mean place have been computed to April 30.

The ledgers of meridian observations 1912–16 have been completed for press, and a catalogue formed from them which is

ready for press except for a final correction to the right ascensions on account of the equinox.

The meridian observations of the sun, Venus, and Mercury during the years 1912–16 have been completely reduced and compared with the corresponding tabular quantities. A discussion of the results of these observations is well advanced. The whole of the tabular matter has been completed for press.

The circumpolar observations of 1916–18 have been completely reduced and discussed in detail. The final completion for press is, however, postponed until the receipt of the results of observations of the "latitude variation" from the international stations. Rigorous ephemerides, based on these observations in combination with earlier results, have been computed for 33 stars.

In connection with the Cape Astrographic Zones, a catalogue of the right ascensions and declinations of the standard stars, based on the combined evidence of the meridian and photographic observations, is in course of preparation. During the year the results for zones 41° to 48° have been completed for press, and ledgers have been formed for stars contained in zones 49° to 51°.

A commencement has been made with the transformation of the rectangular co-ordinates into spherical co-ordinates of a number of additional stars, limited to stars of 9th magnitude or brighter on the C.P.D. scale.

Researches on the relation between magnitudes and distribution of stars have been continued with a view to establishing the laws of density and luminosity of the stars which represent the most recent data of observation.

Miscellaneous.—The time-signal service, meteorological observations, and seismograph records have been maintained as in previous years.

Royal Observatory, Edinburgh. (Director, Professor R. A. Sampson, F.R.S., Astronomer Royal for Scotland.)

General.—War conditions throughout the year have again severely restricted the work which it was possible to do. Mr. J. Storey and Mr. R. W. Wrigley have continued in the employment of the Admiralty. Further, Mr. E. A. Baker, the sole remaining scientific assistant, was away from duty for nine months owing to a serious illness and slow recovery. The claims of war service have also interfered with the supply of lady computers.

Time-Service and Transit-Circle.—This is the only section of the observatory work which it has been possible to advance with some effect. The studies on clocks, time-keeping, and time-measurement have been pursued with as little interruption of plan as was possible. It is intended hereafter to develop these so as to embrace all problems connected with the rotation of the earth. The clocks chiefly studied have been the Riefler clock and the two synchronome clocks with W. H. Shortt's escapement. The former of these has continued to show an accelerated gaining rate, of the

order of $-^{s}\cdot 01/(\text{day})^2$, as for several years past, occasionally in abeyance but always reappearing. No clue as to the cause of this is forthcoming so far. The second synchronome clock was fitted at the observatory with a new link, connecting pendulum and crutch, embodying a suggestion of Mr. E. T. Cottingham. It has kept a very uniform rate and arc throughout the year. A similar link has been fitted to Synchronome I. without, however, abolishing the acceleration of rate. Arrangements are in progress for greatly enlarging the space in which it is open to study clocks or other instruments under constant temperature conditions, by taking in the whole of the basement of the east dome, around the present clock cellar. This is in order to meet the suspicion that the clocks may affect each other when they are too close together.

Another clock has been added for examination, by the kindness of Mr. W. F. King, who designed and made it. The maintenance is a chronometer escapement applied at the bottom of the pendulum. In this position the impulse is five or six times as effective as one applied in the usual place, and may therefore be made proportionately lighter. The present model is not in an air-tight case, but after sufficient examination it is intended to rebuild it with any improvements experience may dictate. A paper describing the microchronograph, taking time from the various clocks consistently to $^{s}\cdot 001$, was published in *Monthly Notices* for June.

A good deal of attention is being given to anomalies shown in the records of the ordinary Fuess chronograph and the performance of the relays required; progress has been made in elucidating them.

A second member of the series of papers on "Clocks and Time-keeping" has been published in *Proc. R.S.E.*, vol. xviii. part ii., giving tables of the circular equation. A third paper, on "The Air Resistance to a Free Pendulum," is in preparation.

Time determined at the observatory has been compared with that of Paris as issued by rhythmic radio signals, and the results telegraphed to the Observatory of Paris the following day.

Other Instruments.—The 15-inch equatorial and solar spectroscope have been unemployed throughout the year. With a view to employment of the 24-inch reflector on photo-electric and other photometric work, the question of using the present defective mirror or of replacing it was considered. One feature of such work is that it does not demand a perfect mirror, since it may be done with an out-of-focus image. But a reluctance was felt in starting with a faulty tool, because an interruption would ensue if it were afterwards found advisable to amend it. Arrangements have therefore been made with Mr. George Calver to supply a new 24-inch mirror.

Astrographic Chart.—Revision of the magnitude determination of the zones $-38°$, $-39°$, $-40°$ has proceeded, the old measures of diameter of image, which were found to be extremely subject to personality, being set aside in favour of comparison with an eyepiece scale of photographed images of a star. For part of the year Miss J. C. Falconer has been engaged on them, and for

part Miss K. A. Williams, but difficulty has been found to obtain ladies to train for the work. Zone $-40°$ is completed, and a start has been made with zone $-39°$.

Meteorology and Seismology.—The regular observations have been maintained and records read up to date. A Dines float barograph has been constructed at the observatory to replace the large old Casella barograph, which has proved very insensitive. This, along with the microbarograph, will be kept at constant temperature. The Milne seismograph is to be replaced shortly by a damped Milne-Shaw instrument, lent from Eskdale Observatory.

Armagh Observatory. (*Director, Rev. W. F. A. Ellison.*)

Owing to the unfortunate illness and death of Mr. J. A. Hardcastle, soon after his appointment, and the delay in the appointment of his successor, the observatory was practically derelict from 1916 October to 1918 October; and, except for the meteorological observations, which were kept going by the assistant, the Rev. Charles Faris, no work was done. Since the present director took charge on 1918 October 15, much time has been occupied with necessary overhauling and cleaning of the instruments.

The 10-inch Grubb refractor is now in good condition and has since been used on all favourable nights, for the examination of planets, double stars, and nebulæ; the object-glass is a fine example of Grubb's work, showing the *comes* to δ Cygni and the sixth star in θ Orionis with ease, even in poor air, and the companion to Sirius whenever the definition is at all good. The mural circle was used to observe star transits for time purposes.

An 18-inch Calver reflector has been added to the equipment by the director.

Cambridge Observatory.
(*Director, Professor A. S. Eddington.*)

The meridian observations for the Cambridge Zodiacal Catalogue were concluded on June 29; nearly all the desired observations were obtained. From the beginning of the year to that date the stars were observed on 28 nights, and 631 measures of right ascension and 673 of declination were made. The star-corrections have been calculated, and the observations of 1917 and 1918 are completely reduced to mean place. A beginning has been made with the calculation of the star corrections for the observations in 1910–14, which remain in arrear. It is not intended to start any new observing programme with the meridian circle at present.

The introduction to vol. xxv. of the *Cambridge Observations*, which contains the ledgers of observations of the Cambridge Zone Catalogue (1875·0), has been printed, and it is expected that the volume will be distributed during the spring.

The Sheepshanks equatorial has been used for determination

of photographic magnitudes and effective wave-lengths of Nova Aquilæ. Photographs were taken on 27 nights from June 13 to August 20. The magnitudes are ready for publication; they exhibit some well-marked fluctuations of the light, which have been found also by other observers. The effective wave-lengths, determined with a coarse grating, are now being measured.

The Saturday evening exhibitions of celestial objects with the Northumberland telescope have been well attended, notwithstanding the depleted state of the University. The regular demonstrations in practical astronomy have been suspended; but instruction and opportunity for practice with the instruments have been given to two graduate students.

The post of Second Assistant, vacated by the death of Second-Lieut. Entwistle, was filled by the appointment of Mr. H. E. Green on June 20. A successor to Mr. Hartley, First Assistant, has not yet been appointed.

Solar Physics Observatory, Cambridge University.
(Director, Professor H. F. Newall.)

Spectroheliograph.—Photographs of the sun's disc in K_{2-3} light have been obtained on 126 days (previous year, 151), and photographs of the prominences at the limb on 120 days (previous year, 144).

The general activity of the sun now appears to be on the decline in the eleven-year cycle; and the intervals between the larger outbursts are becoming longer.

For the year 1917 October 1–1918 September 30 the Director of the Kodaikánal Observatory has sent 341 spectroheliograms showing the solar disc in K_{2-3} light. Of the 24 days missed in the Kodaikánal record during this interval, the Cambridge record has photographs for 10 days.

The Kodaikánal records have been subjected to a rough preliminary examination in search of evidence of systematic distribution of the calcium flocculi. The work is being continued.

Photoheliograms.—Daily photographs taken with the photoheliograph at Dehra Dûn have been received, and the negatives are stored at the Science Museum, South Kensington. Positive prints have also been received from Dehra Dûn. The work of mounting the prints has been resumed in the last month of the year. Negatives and silver prints for the interval 1917 August 16–September 5 are reported as lost through enemy action.

Spectra of Sun-spots.—Photographs to the number of 83 have been taken of sun-spots and other features on the sun's surface in the summer months. Some interesting features relating to the displacement of lines over the umbræ are being studied in detail.

Monochromatic Solar Images.—A new method of obtaining monochromatic images of the sun was tried in the early summer, and a more careful trial is to be made again in the coming year.

Study of Sun-spot Records.—The study of the areas and life-history of sun-spots from the Greenwich records 1889–1901 was resumed in the last month of the year.

Stellar Spectra.—Observations of Nova Aquilæ III. (1918) were begun on 1918 June 9, on which day news of the outburst was received from the Astronomer Royal. Out of 35 plates exposed in the new spectrograph attached to the 15-inch Huggins refractor, many contain valuable records of the changes in the spectrum of this very interesting Nova. The photographs obtained on June 13 and 15 have been studied in detail, and a note on some of the results was communicated to the Society in November (*M.N.*, 79, 31). The conclusion drawn from this examination is that the narrow absorption lines in the spectrum of the Nova on June 13 are absorption effects similar to those characteristic of α Cygni when duplicated by two large displacements, corresponding with those of the absorption lines of hydrogen in the Nova. This result is of special interest as showing that the absorption lines of hydrogen are seen in their entirety, and are not in part masked by encroachments of the emission lines of hydrogen.

In continuation of the work which is being carried on with regard to the classification of stellar spectra, the spectra of stars which are of the Harvard class A have been subjected to a careful scrutiny, and working lists have been prepared with a view to obtaining further information on minute detail, which may lead to the adoption of more definite criteria for the arrangement of the sub-types in this group.

A revision has been made of a paper published by the Solar Physics Committee in 1913 "On the Unknown Lines in Celestial Spectra." Lines, which have since the publication of that paper been traced to their chemical origin, have been eliminated from the previously published list, and other lines of unknown origin have been added, which in the same interval have been recorded in various publications on stellar and other celestial spectra.

Investigations in Atmospheric Electricity.—The quantitative investigation of the electrical phenomena of the atmosphere have been continued. The records obtained in the photographically recording apparatus have been measured, and the results are nearly ready for publication.

Staff.—Of the four members of the staff who have been absent on war duties, two returned to duty at the observatory in December. Lieut.-Col. Stratton and Lieut. W. E. Rolston are still in France.

Dunsink Observatory. (*Director, Professor H. C. Plummer, Royal Astronomer of Ireland.*)

The general state of the sky during 1918 has shown a distinct improvement as compared with the previous year. The number of fairly fine nights was 60, and though many of these coincided

with bright moonlight, a total of 202 plates was secured with the reflector on 57 nights. The objects observed included RS Boötis, RR Ceti, Y Lacertæ, Y Aurigæ, the irregular variable B.D. + 56°·547, the eclipsing variable W Ursæ Minoris and the Wolf-Rayet stars B.D. + 35°·4001 and 4013, B.D. + 36°·4456 and 3987, and B.D. + 38°·4010. The number of plates measured was 194. In addition, Professor Bailey's light curves of 277 variables in the clusters ω Centauri, M3 and M5, have been submitted to harmonic analysis.

The time-service to Dublin has been continued as in previous years, clock error being determined with the meridian circle on 99 nights. Mr. Martin remains as sole assistant.

Glasgow Observatory.
(*Director, Professor L. Becker; Assistant, James Connell.*)

The Director has been on leave of absence throughout the year, and the usual routine work connected with the time-service and meteorological observations has been carried on by the assistant.

In addition to the above, the assistant has had under his care a number of chronometers and watches belonging to the Admiralty, and has carried on the work of an Admiralty Chronometer Depot.

Owing to the astrophotographic lens belonging to the large spectroscope being still on loan to the War Office, advantage could not be taken of the appearance, in June, of Nova Aquilæ to obtain a photograph of its spectrum.

Hill Observatory, Sidmouth.
(*Director, Sir Norman Lockyer, K.C.B., F.R.S.*)

Since the date of the last Report no observations have been made, owing to the absence of the staff.

The instruments and accessory apparatus and buildings are all in good condition, but the repair to the rail of the Kensington dome has not yet been made, owing to the shortage of labour.

The library has been increased by the gifts of many transactions and pamphlets from various observatories and from the Director.

Steps are being taken to restart work at the observatory as soon as possible.

The Annual General Meeting of the Hill Observatory Corporation took place in June last.

Liverpool Observatory, Bidston.
(*Director, Mr. W. E. Plummer.*)

The work of the observatory during the past year has been much restricted by the provisions in the Defence of the Realm Act having reference to artificial lighting and to the control of

marine chronometers. The demands for information in unusual directions have also been many. Prominent among these were the provision of additional meteorological observations required for war purposes and data for assisting the anti-aircraft service. Both of these demands have now been withdrawn, but too recently for the observatory to have recovered its normal condition and activity. Owing to the scarcity of paper and difficulties connected with labour supply, no annual report was issued by the Mersey Docks and Harbour Board.

Application has been made to the Post Office for the return of the wireless telegraphic apparatus, and though the conditions imposed on re-installation are severe, it is hoped to be able to resume the collection of local meteorological information in order to correct the published tidal predictions. It may be said that these continue to be unsatisfactory, but how far the erratic character is attributable to local causes mentioned in the last Report or to defective general theory has not been determined. The semi-diurnal tide apparently needs very considerable correction.

The seismological work is continued, and arrangements have recently been made to ensure closer co-operation with the Oxford University Observatory and other earthquake-observing stations.

Radcliffe Observatory, Oxford.
(*Director, Dr. Rambaut, Radcliffe Observer.*)

In the Report for 1917 it was stated that the work of this observatory during the year had been hampered and restricted by difficulties of various kinds. The year 1918 has proved still more unfortunate.

Mr. J. G. Balk, who joined the Forces on 1915 January 1, has been absent on military service for the whole year.

Early in the year Mr. H. G. S. Barrett, third assistant, was called up, and has been absent on service since January 18.

Later in the year the observatory suffered a further loss through the retirement of Mr. W. Wickham, F.R.A.S. For some time he had been suffering from continually recurring ill-health, and for more than a year had been unable to give much effective assistance. He retired on July 1, after nearly thirty-eight years of honourable service at the observatory, having been appointed first assistant in November 1880.

Of the former staff, therefore, there remained only Mr. W. H. Robinson, second assistant. Within a few days of Mr. Barrett's departure a youth of fifteen years of age was engaged as boy-computer.

It will be remembered that this is a meteorological as well as an astronomical observatory. The meteorological records extend continuously over a great many years—the rainfall observations, for example, over more than a century—and any breach of continuity in these records would very much reduce the value of the whole.

Whilst, therefore, it was clear that we could not hope to keep up all the different branches of our activity as before, and that something would have to be sacrificed, it was felt that an effort should be made to continue these observations uninterruptedly as far as possible through the emergency period.

Some of our meteorological results, also, were required for the use of the Royal Air Force, and were supplied daily to Major H. H. Kitchener, R.A.F., while in command of a training squadron on Port Meadow (Oxford), and to Captain A. J. Hember, at the Aerodrome, Bicester.

The astronomical department has consequently suffered, as compared with the meteorological, out of proportion to the relative importance which we attach to it under normal conditions.

In the early spring months nine proper-motion plates were taken with the 24-inch photographic refractor, thus clearing off the last of the fields in our observing list which had hitherto escaped us. During the year two dozen plates were stored, undeveloped, in air-tight boxes, making in all fourteen dozen thus disposed of. This completes the first stage of the work allotted to the Radcliffe Observatory in accordance with Professor Kapteyn's "Plan of Selected Areas," all the areas selected in the northern hemisphere having been photographed at least twice. The final stage, consisting in exposing for a second time after an interval of ten years the plates so stored, or photographing the same areas for a second time, would in ordinary circumstances commence in the autumn of 1919, and it is hoped that under the happier conditions now prevailing the staff may be restored to something like its normal strength, and that we may be able to attack this stage of the work with full vigour.

During the summer and autumn months a number of observations of the new star in Aquila were made by the Radcliffe Observer and Mr. Robinson. Observations of the brightness and colour of this star were made on 100 nights between the date of its discovery and December 10, with the naked eye, with opera and field-glasses, and occasionally with the 10-inch Barclay refractor. This series of observations, including a few observations made by Mr. Barrett in the early days of June in the intervals of his military duties (Mr. Barrett independently recognised this object as a new star on June 9), containing 155 sets (644 separate comparisons), has been reduced, and the results communicated to the Society at its meeting in December. This paper, which contains a diagram exhibiting the changes of magnitude of Nova Aquilæ and a comparison with those of Nova Persei, 1901, appears in the *M.N.* for December 1918.

Volume lii., part ii., of the *Radcliffe Observations*, containing the results of meteorological observations made during the year 1917, was printed and a limited number of copies distributed in the usual manner.

University Observatory, Oxford.
(Director, Professor H. H. Turner.)

Volume iii. (zone $+62°$) of the Vatican portion of the Astrographic Catalogue was published in April last, and the printing of vol. iv. ($+61°$) is proceeding slowly, owing to war conditions. The reductions of zone $+57°$ are complete to R.A. $4^h\ 42^m$. Some work has also been done on new plates substituted for poor originals. But the supply of material from Rome has not occupied quite half the time of the computer available, and it was thus fortunate that the Government Grant Fund had been able to make a grant for the measurement and reduction of plates in the Santiago zone $-22°$, as suggested in the last report. Fifteen of these plates, chiefly in the Milky Way, and containing some 13,500 stars in all, have been measured and fully reduced, with satisfactory results. One point is of special interest. When the first batch of plates was received from Santiago, we found to our dismay that the réseau lines were not continuous; only a small portion in the middle of each side of each square was ruled, the corners being left blank. For a wire moved by a screw this was doubtless enough; but for the method of measurement by a scale such a réseau was useless. After some hesitation it was determined to try superimposing a réseau, but as war conditions made it impossible to devote a réseau plate permanently to each star-field, a method had to be devised for holding the superimposed réseau firmly during measurement, while allowing for its ultimate detachment for further use. The following plan was adopted: the edges of the réseau plate were cut off, so that when it was placed (film downwards) on the star-plate there was a margin all round. The réseau was adjusted by hand until rough measures of a few stars showed that the plate constants were small: then small slips of glass were cemented round its edges to hold it firmly. The security has been tested by check readings in the corners of the plate of the original broken réseau, and no shift amounting to half a unit has been detected during measurement, except in one instance (after the plate had been completely measured), which may confidently be referred to a cause not likely to recur, viz. a closely adjacent bomb from a Zeppelin. When the measurement and revision are complete, the auxiliary slips of glass can be detached from two adjoining sides of the réseau plate, thus releasing it, while leaving the other slips as guides for replacing it, if necessary. The mean error of centring a plate by this method is about $3''$ or $4''$ only in each co-ordinate, and the orientation correction is almost eliminated.

The meteorological investigations are proceeding as opportunity offers. A large number of series of various elements show the "chapters," though the idea of simultaneous terminations for all elements and all places will probably prove untenable. The relation of the "chapters" to the movements of the earth's pole was shown in the May number of the *Monthly Notices*.

The seismological work has also been continued. By the kindness of Mr. J. Walker the roomy basement of the Clarendon Laboratory (in which Mr. C. V. Boys made his classical Cavendish experiment) has been temporarily put at our disposal, and Mr. Shaw mounted therein one of his modern machines in October last. Much information of value has already been thus obtained.

The editing of Baxendell's long-period variable observations has now been completed, with the able and industrious volunteer co-operation of Miss Blagg. A few complete sets of the dozen papers have been bound in volume form, and distributed to those likely to be specially interested.

Several new zones of the Astrographic Catalogue have been "counted," and something like a definitive reduction, in which the galactic condensation is first eliminated, is now being attempted step by step.

Students are beginning to return to Oxford and to the observatory, and numerous lectures have been given during the year to troops. The Director visited France in March and again in November for this purpose.

The Coats Observatory, Paisley.
(Convener, Rev. Charles A. Hall, F.R.M.S.)

Throughout 1918 the work of the observatory—astronomical, seismological, and meteorological—has been carried on as usual without interruption. Observations are regularly reported to the Meteorological Office. The several recording instruments are in good order.

Imperial College, South Kensington. *(Professor A. Fowler, F.R.S.)*

The astronomical instruments were chiefly used for the instruction of students, but occasionally also for spectroscopic observations of sun-spots and prominences. The 6-inch equatorial was also employed for visual observations of the spectrum of Nova Aquilæ, the results of which were communicated to *Nature* during June and July. No photographs could be taken, as the photographic telescope is included among the instruments which are still detained at the Poulkovo Observatory.

Owing to the absence of all assistants, but little time was available for research work in the spectroscopic laboratory. Some progress was made, however, with the investigations of the line-spectra of silicon, carbon, and oxygen under varying conditions; in particular, the region covered was extended so as to include the part of the spectrum lying between 2000 A and 1850 A.

Considerable time was occupied in connection with work arising out of the war.

Stonyhurst College Observatory.
(Director, Rev. W. Sidgreaves, S.J.)

The meteorological, magnetic, and seismological observations have been carried on as usual. Observations of the solar surface made on 200 days include 199 drawings on as many days, and notes without a drawing on 1 day. Of the drawings, 169 are complete, showing all spots and faculæ, and the remaining 30 are complete, so far as the spots are concerned, but wanting the full record of the faculæ. The visible disc was never found spotless throughout the year.

The mean disc-area of the spots (in units of 1/500 of the visible surface) stands at 7·9, as against 12·1 for the previous year; and, taking the spot-area for index, solar activity has steadily declined since the great maximum in August of 1917.

A good series of spectrograms of Nova Aquilæ (1918), covering the period June 10 to October 23, was obtained with the Thorp and Whitelow prismatic cameras. The spectroscopic results for the total solar eclipses of 1911 and 1914 were finally reduced, and the results were presented to the Society.

Various calls have been made for popular lectures on astronomy to the troops in home camps and in hospitals, which have been gladly accepted. The lectures were given by Father Cortie.

Mr. A. A. Buss's Observatory, Chorlton-cum-Hardy, Manchester.

Telescopic and spectroscopic observations of the sun were possible on 144 different days during the year under review, and were mostly made with the 6-inch Simms O.G. lent by the Society. The impression has been created that during 1918 the maximum period of the present activity-cycle has been reached, if not actually passed, and the persistent low latitude of most of the spots and spot-groups lends additional probability to this.

As regards spectroscopic features seen over eruptive areas on the solar disc, several fine instances were recorded of D_3 brilliantly reversed, adjacent to dark absorptive areas seen in the same radiation, absolutely in the same way and simultaneous with similar effects seen in H_α, etc., the motion-forms in both helium and hydrogen being practically identical. Again, helium D_3 absorption effects were seen on numerous occasions, not only over the extra active areas between the two main components of a spot-pair, or at the immediate rear of a single spot, but also frequently over purely faculic areas. The D_3 line, however, was never seen in absorption *over a spot-umbra.*

The presence of many and often stupendously large absorptive formations, best seen in H_α, and frequently partaking of violent motion, was noted on many days, and indeed these dark flocculi formed quite a feature of the period under consideration, specially

so during the later summer months. The "claw" effect was observed in many cases, and it is no doubt the spectroscopic presentation of the solar tornadic column or trunk, the upper portions of which give rise to the whirlpool design of the surrounding region when photographed in H_α. The phenomena just described can be seen with ease, even with a small telescope, so long as the spectroscope attached to it is really efficient.

Regarding chromospheric phenomena seen on the limb, several exceptionally fine instances were recorded of the reversal into bright lines of the dark lines throughout the entire visible range of the spectrum; in fact, the general background between the lines was so suffused with light that the arc under observation formed a ribbon of brilliant light everywhere, yet at the same time no eruptive prominence was seen to rise over the region so intensely active.

Several instances of magnificent eruptive prominences were noted. In one case (August 14, in the low S.E. quadrant), on account of the high velocity the entire huge formation was invisible with a moderately narrow slit, being wholly projected upon the red side of it; it reached fully 12 units of the scale away from the normal at the apex of the gigantic fountain spray, which reached a radially measured altitude of quite 150,000 miles, but being inclined to the line of sight, its path must have been far greater. The number of prominences seen during the year under review was many hundreds, amongst which there was a fair number of polar ones. There were also several instances of immense long ranges of prominences apparently cut off sharply at the top along a line concentric with the general contour of the sun's limb. Again, the interposition of dark masses in front of bright prominences was seen on many occasions, and was not confounded with the mere effect of "interspaces."

The year under review also embraces several observations of the aurora borealis, the zodiacal light, and of extraordinary diffuse luminosity of the night skies with no moonlight whatever.

Wolsingham Observatory. (*Rev. T. E. Espin.*)

The work of searching for new double stars in the selected zones has been continued throughout the year with the 17½-in. and 24-in. reflectors, and the results have been communicated to the Society. Occasional observations have been made also of some red stars and suspected variables. Estimations of the magnitude of Nova Aquilæ were made during the autumn on all fine nights.

Mr. A. M. Newbegin's Observatory, Wallington, Surrey.

Bad weather throughout the latter half of the year greatly hindered the record for prominences being maintained at its usual standard.

The results are again given in tabular form:—

Number of observations	= 108
,, prominences	= 1452
Daily average	= 13·44
Daily average height	= 43″
Distribution:—	
Prominences in N. hemisphere	= 684
,, S. ,,	= 768
,, E. limb	= 776
,, W ,,	= 676
,, under 30″ in height	= 517

Metallic prominences were recorded on 66 days in 97 outbursts and very active disturbances were observed on four occasions.

The results show very clearly the transference of maximum activity from the northern hemisphere to the southern, while the preference for the east limb is still maintained.

The average height of the prominences shows a decrease of 3″·0 of arc as compared with the previous year.

Some work on the displacement of the Hα line has been attempted.

Mr. G. J. Newbegin's Observatory, Lyndale, Sutton, Surrey.

In the year 1918 seventy-seven observations of Solar Prominences were made, as compared with seventy-eight in 1917. As compared with the previous year, the number of prominences observed was one in excess, viz. 836, the mean daily average being 10·8; the mean daily average in height was 32″·7. Dark absorption was not so pronounced as in the previous year; also the general tendency of activity was towards the South, this being especially noticeable in the two polar regions.

The brilliant bright lines in the spectrum of Nova Aquilæ, as seen with a Browning spectroscope, were of very great interest.

Rousdon Observatory, Devon.
(Sir Wilfrid Peek's; Mr. C. Grover, Observer in Charge.)

The building is kept in good repair, and the $6\frac{4}{10}$-inch equatorial is in perfect order. Weather has been very changeable: the three best observing months were March, June, and November. On several nights toward the end of the year the midnight sky on moonless nights was singularly luminous. The early evening hours were often intensely dark, but towards midnight a distinct glow suffused the sky: on the last night of the year this was generally noticed. Observations were made on 134 nights; those of the long-period variable stars were continued on the same lines as in former years; 447 magnitudes were determined, making

a total of 14,139 magnitudes during the thirty-three years this work has been in progress. 508 maxima and 356 minima have been observed. Nova Aquilæ was observed from June to December.

Observations of stars are taken with the transit instrument when required for regulating the sidereal clock. The usual meteorological observations are also regularly continued.

The Rev. T. E. R. Phillips's Observatory, Headley, Epsom, Surrey.

In the early part of the year systematic observations were made of the planets Mars and Jupiter, and of the latter again during the closing months.

A number of double stars, including Sirius, have also been measured with the Coleman equatorial belonging to the Society, and special attention has again been given to the stars ξ Boötis and 70 Ophiuchi.

After the outbreak of Nova Aquilæ a number of spectrograms were taken by using an objective prism covering $2 \times 2\frac{1}{4}$ inches of the O.G. of a 3-inch finder. One or two of the plates have been measured, and the resulting mean velocities given by the two sets of displaced hydrogen lines on June 13 are -1417 and -2247 km./sec.

The last plate was taken on November 16, at which time the hydrogen bands were feeble, though still present, and the spectrum was predominantly nebular.

The meteorological observations have been continued.

Mr. Reynolds' Observatory, Harborne, near Birmingham.

During 1917 and 1918 very little has been done with the 28-inch reflector except a series of photographs of Jupiter with the Cassegrain arrangement of mirrors. The weather conditions were not good as a rule, and although hundreds of images were obtained, only about 10 per cent. were worth preserving. At the same time, the best of the photographs are useful records of the photographic intensities and positions of the belts and zones. Lantern slides of these have been presented to the Society. A great deal has been done in the autumn of 1918 to bring the instrument into good condition for stellar work, which, owing to circumstances connected with the war, could not previously be undertaken.

Mr. F. Sargent's Observatory, Horfield, Bristol.

The last report from this observatory appeared two years ago. At that time observations of Jupiter were proceeding which ultimately produced a useful record for the "opposition."

Later, work became intermittent on account of frequent absence from the observatory due to the abnormal times, with the result that Jupiter observations for the "opposition" 1917–18 were fewer in number, and lacked the continuity which is so essential.

With the return of more normal conditions, these observations were resumed in the early days of August last, and have been consistently followed up to the present time. In view of interesting changes now occurring on the Jovian surface, the record of the present season should prove useful.

Satellite phenomena have received more attention, and have produced some interesting results.

The other planets, and cometary visitors, have also come under observation, and a programme of double-star measures entered upon, but temporarily abandoned, is being resumed.

During the month of May last the observatory and its equipment were moved to their present position, where it is hoped to reap the benefits of greater elevation, more open surroundings, and other advantages.

Dr. W. H. Steavenson's Observatory, West Norwood.

Very little work was done in the early part of the year.

On June 8 Nova Aquilæ was independently detected, and from that date until the middle of November regular observations of the star were made with the 15-inch reflector, special attention being paid to changes of colour. A few visual spectroscopic observations were also made.

The results of the earlier observations have been communicated to the Society.

Estimates of the magnitude of the Nova have been made with the naked eye and with field-glasses, and the results communicated to the British Astronomical Association.

An unusual number of fine, or partially fine nights, followed the discovery of the Nova, and observations of the latter were secured on no less than 70 out of the first 90 nights after its appearance.

Mr. Harold Thomson's Observatory, Newcastle-on-Tyne.

The instrument in use is a 12½-inch silver-on-glass reflector, by Calver, kindly lent by Mr. W. F. H. Waterfield during his absence abroad. The 8½-inch reflector is at present dismantled. Regular observations have been carried out on the surfaces of Jupiter, Mars, and Saturn, and on about thirty long-period variable stars. The results have been communicated to the British Astronomical Association.

Nova Aquilæ III. was observed on June 8 and reported by telephone to the Royal Observatory, Greenwich.

Estimates of the magnitude of the Nova have been made

whenever possible up to the middle of December, and the visual spectrum has been constantly examined since June 8. Some of the results have been communicated to the Society and to the British Astronomical Association. Wolf's and Borrelly's comets were observed on several occasions, but presented no feature of special interest.

Helwân Observatory, Ministry of Public Works, Egypt.
(Director, Mr. H. Knox-Shaw.)

No work of an astronomical nature was done during the year except the maintenance of the time-service and the taking of observations of solar radiation. The same meteorological, seismological, and magnetic observations were taken as in 1917.

It is hoped that it will be possible to resume the usual activities of the observatory during the course of 1919.

Kodaikánal and Madras Observatories.
(Director, Mr. John Evershed.)

The routine work of the observatory dealing with sun-spots, flocculi, and prominences, was continued on the same lines as formerly, and spectroheliograms in K light were taken on 337 days, Hα images on 261 days, and photoheliograms on 303 days.

The large grating spectrograph was employed mainly in researches connected with displacements of the solar lines, the programme of work including photographs of the spectrum of Venus with Fe arc comparison lines, also control plates of sunlight and Fe arc. A good series of third and fourth order plates of the carbon arc and solar spectra was secured for measuring the displacements of the cyanogen band-lines near λ 3883. During a spell of exceptionally clear sky in February and March about fifty solar rotation plates were also obtained.

The Venus Spectra.—In the six months April to September inclusive, high-dispersion Venus spectra were obtained on twenty-seven mornings. These, and 31 plates of sunlight spectra, have all been measured by the positive-on-negative method, and yield results of great interest.

At the western elongation of the planet, when the angle Venus-Sun-Earth was about 45°, the displacements of the iron lines towards red were found to be only slightly smaller than in the control spectra; but there is a progressive diminution of wavelength as the angle at the Sun increases. When this angle exceeds 90° the displacements Sun-arc all have the minus sign, that is, the solar lines reflected by Venus are displaced towards violet instead of towards red.

It also appears that the more affected lines diminish in wavelength more than the less affected lines, so that when the light is

derived from a hemisphere of the Sun turned about 90° to Earth, the Fe arc and solar lines nearly coincide.

The result of the Venus work seems to dispose finally of the possibility that the solar line-shifts are due to the gravitational effect resulting from Einstein's generalised relativity hypothesis. As the shift towards red of the solar lines, according to these observations, is only observed in the light derived from a hemisphere of the Sun facing towards Earth, it seems necessary to admit an Earth effect whether the shift is interpreted as motion or otherwise. It is very desirable that confirmation of these results should be obtained independently by other observers.

The Venus spectra obtained in 1918 leave still undecided the question of the rotation period of the planet. Four excellent plates obtained in 1917 November and December, near the eastern elongation of the planet, give consistently low values of the orbital velocity, but this may be interpreted in two ways: either the planet rotates in the same direction as the Earth and with approximately the same period, or the Sun-arc displacement for any particular line is not constant but is liable to considerable changes.

The plates taken at western elongation in 1918 April give nearly the calculated orbital velocities, but as it was found impossible, owing to bad definition, to keep the planet in a fixed position on the spectrograph slit during the long exposures, the resulting spectra represent more or less the integrated light of the half disc, including rays from parts of the planet approaching the Earth, and from other parts receding from the Sun, resulting in a partial compensation of the effect looked for.

The uncertainty as to the effect of the planet's rotation, and the possibility of variations in the wave-lengths of the solar lines, make it useless at present to derive a value of the solar parallax from the determinations of orbital velocity. Observations have been instituted, however, to test the constancy of the Sun-arc shift. Plates taken at weekly intervals in September, October, and November indicate only very small changes when longitudes on the Sun differing by 90° are compared; but monthly tests will also be made extending over a much longer period.

In photographing the spectrum of Venus with the grating spectrograph in the blue and violet regions, it was noticed that longer exposures were required than is necessary when the image of a brightly-illuminated terrestrial cloud is brought on to the slit. Direct comparisons of the spectra in a low-dispersion prism spectrograph, using a parabolic mirror to form the image of Venus, showed that, with exposures regulated to give equal density in the green region, the Venus spectra are much weaker in the violet than the cloud spectra, suggesting that the atmosphere of Venus is devoid of clouds, or, if these are present, the atmosphere above them must be strongly absorptive for the violet rays.

The Cyanogen Bands.—The measures of the cyanogen band-lines in the Sun and in the carbon arc have shown that most of

the lines are shifted towards red, both at the centre of the disc and at the limb, and, as in the case of iron, the stronger lines give the larger shifts. The shift at the limb is on the average greater than at the centre of the disc, but is less than the theoretical gravitational shift equivalent to 0·634 km./sec. A systematic difference was found between north and south polar limbs, which requires further investigation.

The Solar Rotation.—The results of measures of ten strong lines of Fe and Ca in the region of Hα show that, notwithstanding the increased accuracy of measures made by the positive-on-negative method, large discordances are still found in the rotation velocity for individual plates The mean value for the sidereal velocity at the equator in 1918 March and April is 1·92 km./sec., and for the Hα line 2·05 km./sec. The average probable error of a plate is ±0·006 km./sec., but the measuring errors are found to be smaller than the plate irregularities, so that this value seems to represent the limit of accuracy practically attainable in solar rotation work when the mean of ten lines is taken.

It is considered a waste of time to measure a larger number of lines in order to improve the p.e., in view of the large differences found in different plates. These differences are probably due to local displacements of the lines, which recent observations have shown to occur frequently in different parts of the Sun's disc.

Nova Aquilæ.—Two series of prismatic camera spectra of the Nova were obtained between June 12 and July 11, and the results of a study of these have been communicated to the Royal Astronomical Society. The changing wave-lengths of the double series of hydrogen absorption lines and of the enhanced lines of iron suggest an analogy with the solar eruptive prominences, for Kodaikánal photographs have proved these to move out from the Sun with accelerating velocity, indicating the action of a repulsive force which is probably operative also in novæ. The hydrogen emission bands in the Nova are shown to have widths proportional to wave-length, which would not be the case if pressure or density were concerned in the widening; it is therefore considered to be a Doppler effect also, due to a vast explosion or expansion of the gases in all directions. The narrow absorption line H which is found superposed upon the broad emission band Hε is shown to have a displacement which is almost the same in amount and sign as that due to the solar motion in space, implying a stationary condition of the calcium vapour with reference to the sidereal system: it probably has no connection with the star, and appears to be widely distributed in the Milky Way region.

Publications.—Bulletins Nos. 58 and 59, dealing with the prominences of the second half of 1917 and the first half of 1918, were issued during the year; but only a few copies were distributed privately outside India.

Madras Observatory.—The time-service of India was maintained, as in former years.

Personal.—The death occurred on November 14 of second-

assistant G. Nagaraja Aiyar, after a partial recovery from a severe attack of influenza.

The late Mr. R. J. Pocock, Director of the Nizamiah Observatory, spent a month at the observatory in May and June. He rendered very effective assistance in arranging the apparatus for photographing the spectrum of Nova Aquilæ, and he undertook a set of measurements of carbon arc and solar spectra, the results of which have been communicated to the *Observatory*.

Nizamiah Observatory, Hyderabad.
(*Mr. T. P. Bhaskaran, M.A., in charge.*)

The observatory has suffered a severe loss by the sad, untimely death of its energetic Director, Mr. R. J. Pocock, B.A., B.Sc., on 1918 October 8.

The astrographic work has proceeded steadily throughout the year, and substantial progress has been made in all stages of the work.

The total number of satisfactory plates measured and reduced during the year is 109, containing in all 45,980 star-images, which, with those measured in previous years (1914–17), makes a total of 642 plates containing 227,086 stars.

Vols. i. and ii. of the Hyderabad Astrographic Catalogue (zones $-17°$ and $-18°$) have been published and distributed during the year.

In zone $-19°$ all the 180 plates have been secured, and the measurement and reductions of 179 plates have been completed. The copy for press of plates up to R.A. $17^h\ 0^m$ has been sent to the printers, and the first eight pages of proofs have been received and corrected. It is anticipated that the volume will be published during 1919.

In zone $-20°$, 109 plates have been obtained and passed for measurement, of which 103 plates have been measured, reduced, and copied for press. As soon as the printing of vol. iii. is finished, the printing of this zone may be started. The instrumental equipment remains the same as in previous years.

Dominion Astronomical Observatory, Ottawa, Canada.
(*Director, Otto Klotz.*)

Meridian Work.—Observations with the meridian circle were obtained on 125 nights. The observations were, as heretofore, divided between the programme of latitude stars under observation and transit observations for determination of clock error and measurement of longitudes. The printing chronograph was used for the registration of transits.

Field observations for latitude and longitude were carried out at two stations, one in eastern Quebec, the other in Manitoba.

The time-service has been maintained as in previous years. There are 9 secondary master-clocks synchronised continuously from the observatory; these in turn control 380 clocks and dials of various kinds. Time-signals are sent out by telegraph and telephone, and the time is recorded on the various seismographs at the observatory.

Astrophysics.—During the year 1918 the 15-inch equatorial has been employed, as formerly, in the determination of the radial velocities of spectroscopic binary stars, with a view of securing the elements of their orbits. 294 plates were secured with the single-prism spectrograph. Six orbits, those of Boss 5173, 19 Lyncis, *h* Draconis, 32 θ^2 Cygni, Boss 1082, and Boss 1275, were published during the year. In the case of the first-mentioned star both spectra were measured, and showed that the components were of about equal mass.

A fairly complete set of observations of the spectrum of the new star in Aquila has also been secured since it made its appearance in the month of June. The spectrum was secured here on the night of June 9, before the star had reached maximum brightness, and before its spectrum had taken on the characteristic "nova" type. The general trend of the changes in the spectrum has been similar to that of other novæ, the characteristic "nova" type giving way to one in which nebular emission became predominant. The fluctuations in light during July were not so rapid nor of so great a range as those which characterised Nova Persei, 1901.

Solar Physics, 1918.—Observations with the 7-m. plane-grating spectrograph and cœlostat with concave mirror of 24·5 m. focal length were continued on the problems outlined in last report. The year was exceptionally cloudy and hazy. Some 275 plates were made, usually having 5 exposures, on each of which are recorded 9 strips of spectrum which register simultaneously various combinations of limb, centre, iodine, and arc spectra, or, in place of the latter, two strips from regions of the sun intermediate between the centre of the disc and the limbs.

It appears that the rate of the solar rotation determined from the spectra of the midway points exceeds that determined from the limb spectra by from 3 to 6 per cent., depending on the region of the spectrum and on the degree of haziness; also that the difference in velocity between groups of weak and of strong lines is greater in the limb than in the midway spectra. These differences are possibly to be explained by the presence of blended spectra of haze, whether of terrestrial, interplanetary, or solar origin.

Spectra of the limb positions in latitude 45° in the four quadrants, photographed simultaneously, when the heliographic latitude of the centre of the solar disc was small, show differences in the velocity of rotation of the two hemispheres which appear to be accidental, not systematic, as Hubrecht has found.

An apparent relationship has been found between numbers of

meteors and quantities of nitrogen compounds in falling rain and snow.

Photometry.—Photographic photometry has been continued by the extra-focal method, the main part of the programme being the investigation of spectroscopic binaries for variability. Observations on 12 Lacertæ have been completed, the period being irregular. Nova Aquilæ No. 3 was observed until about the middle of November, and g Ursæ Majoris and 20 Cassiopeiæ were added to the observing list. One hundred extra-focal plates of star-fields were taken, besides plates for instrumental corrections, and 57 objective-prism plates, mostly of Nova Aquilæ, were also taken.

Geophysics.—This branch of the activities of the observatory comprises seismology, terrestrial magnetism, and gravity. The work of the magnetic survey of the Dominion of Canada was resumed in 1918 May, after an interruption of one season.

As in former years, the three elements, declination, dip, and horizontal intensity, were observed at each station.

During the year 1918 the instruments at Ottawa, together with the seismographs at the University of Saskatchewan, Saskatoon, and Dalhousie University, Halifax, and the undagraph at Chebucto Head, Nova Scotia, all observatory instruments, have been kept in practically continuous operation.

Thirty bulletins have been issued to the various seismological stations of the world, reporting on 141 earthquakes. This is a considerable increase over the 89 earthquakes registered in 1917.

The gravity survey has not yet been resumed, but the publications which were held up during the war, thirteen in number, are now in press and will be issued shortly.

Union Observatory, Johannesburg.
(*Union Astronomer, Mr. R. T. A. Innes.*)

Staff.—There has been no change. Mr. E. L. Johnson has been absent the whole year on military service in Europe.

9-*inch Refractor* (Mr. Innes).—Measurements of double stars and observations of the eclipses of Jupiter's satellites have been continued. A few miscellaneous observations were also made.

Franklin-Adams Star Camera (Mr. Wood).—The following minor planets have been photographed:—5, 26, 44, 75, 173, 409, 431, 692, and an unidentified one; comet Wolf and a new comet discovered by Mr. Reid at Capetown have also been photographed. Plates have also been taken for reproduction in the Observatory Circulars.

Twin Telescope (Mr. Worssell).—A long series of photographic spectra of Nova Aquilæ has been obtained. A few parallax plates have also been taken.

$2\frac{5}{8}$-*inch Talcott Telescope* (Mr. Worssell).—This instrument has been used throughout the year for the purpose of maintaining the time-service.

Blink Microscope.—As in the previous year, work with this instrument has been almost continuous. The Greenwich Zone of +66° has been finished, and the results published in Circular No. 43. The Sydney Zone of −55° has been finished, and that of −57° to 14h. By kind permission of H.M. Astronomer at the Cape, Mr. Wood paid a second visit to the Cape for the purpose of taking repeat chart plates, and got 116 pairs; these are now being blinked. Two further visits to the Cape will be required to fill gaps in this zone. Incidentally some pairs of plates covering a portion of the larger Magellanic Cloud have been blinked, and the results (proper motion and variable stars) have appeared in Circular No. 43.

Meteorological and Seismological Observations.—These have been continued on the same lines as in 1917.

Observatory Circulars.—Nos. 41 to 43 were issued during the year. The chief contents of these are:—No. 41, measures of Southern double stars, dichotomy of Venus, positions of comet 1917 *a* (Mellish) and of several minor planets; No. 42, variable stars; No. 43, proper motions found with the blink-microscope in the Greenwich Zone +66° and in the region of the Nubecula Major. With these circulars the following maps were distributed:— −46°, No. 80; −70°, Nos. 54 and 56; −34°, No. 38. Map −34°, No. 40, was also prepared for distribution with Circular No. 43, but was omitted by the Government printer; it will be included in the next distribution.

Miscellaneous.—Some progress has been made with the literal theory of Jupiter and Saturn. Further difficulties in Hill's theory were adverted to in the *Astronomical Journal* for 1918 March 30, but they have aroused no comment, and it is feared that at present there is no interest in this work. Further progress has been made in comparing the eclipses of Satellites I. and II. observed here with Sampson's tables, and also with a provisional eclipse table so far as concerns Satellite I. At present it seems impossible to reconcile the observations with any theory; the most plausible explanation at the moment is that the rotation of the earth is not constant, and, as far as the evidence goes, the variability is fairly close to that which would account for the irregularities of the motion of the moon as published in the Greenwich volumes since 1908.

If the rotation of the earth is not constant, it would appear—as previously stated by Newcomb (*Astron. Papers*, 60, 247-8)—that one of the best tests resides in the eclipse observations of Satellite I.

Lovedale Private Observatory, South Africa.
(*Dr. Alex. W. Roberts.*)

The main work of the year was that of securing further determinations of the brightness of comparison stars for the Southern variable stars observed at Lovedale.

In this I had, through the kindness of Professor Pickering, the use of the Harvard Meridian photometer. For stars brighter than 6·0 magnitude the mirror photometer was used, the stars being thus related to the Oxford scale and to the Potsdam scale.

Only about a hundred observations of variable stars were made, the main business of the year being the reduction of those secured during the past twenty-six years.

Melbourne Observatory.

(*Dr. J. M. Baldwin, Acting Government Astronomer.*)

Transit-Circle (8-*inch*).—The observations for the year included

	Number of Observations.	
	R.A.	Z.D.
Clock stars	428	310
Azimuth stars . . .	142	132
List stars	390	390
Miscellaneous . . .	19	19
Total . . .	979	851

In addition, on 108 days stars were observed in daylight for clock error for local time purposes.

Collimation has been obtained 73 times; level, 146; nadir, 118; and runs 50 times.

The observation of the list of standard stars for the reduction of the astrographic plates is now completed.

For some years past considerable trouble has been experienced during the winter months by some of the lines of the wire system becoming slack in moist weather. The slack wires have been removed and the declination wire replaced by a new one.

Amongst the wires removed was the central one, and in consequence transits were observed over six wires, instead of over seven as formerly.

Astrograph.—The position of astrographic observer has been vacant throughout the year, and in consequence only plates that were urgently required have been taken. These have included plates with an exposure of 30 minutes with centres along −66°, taken at the request of Mr. R. T. A. Innes for comparison with earlier plates of the same region.

The number of plates taken has been—

Catalogue	1
Zone −66°	29
Adjustment, etc. . . .	4
Rejected	11
Total . . .	45

6-*inch Doublet.*—There has been no observer available for this instrument.

8-*inch Equatorial.*—Observations of variable stars of long period were recommenced with this instrument in April, and it has been employed regularly since then. The results of the observations have been forwarded to Harvard College Observatory each month.

The occultation of Cp_{00} 1824 by Mars on April 11 was looked for, but the star just grazed the southern edge of Mars. The atmospheric conditions were bad, and no change was observed that might not be accounted for by them.

Encke's Comet was observed on four occasions, then followed a long spell of cloudy weather, at the end of which the Comet was too faint to be seen. The results have been forwarded to the *Journal des Observateurs* for publication.

Reduction of Meridian Observations.—The apparent R.A. of all stars to 1918 December 1 is very nearly complete, and the apparent Dec. is complete to 1918 July 31. The mean places of stars in the zone $-64°$ to $-67°$ are complete, the star reductions have been computed to the end of 1916, and those for 1917 are now in preparation.

Proper motions for the catalogue of 6089 stars for 1900 are being computed.

During the coming year no observations except for local time purposes will be made with the transit circle pending the arrival of the travelling wire micrometer, and the whole time of this department will be given to overtaking arrears of reduction.

Reduction of Astrographic Plates.—The measured co-ordinates and diameters have been copied out for the printer to $23^h\,40^m - 68°$.

The plate constants have been computed to $13^h\,21^m - 65°$.

The intercomparison of overlapping plates has been completed to $6^h\,0^m - 66°$ with $6^h\,10^m - 67°$, and discrepancies have been examined up to $14^h\,33^m - 65°$ with $14^h\,24^m - 66°$.

The identification of C.P.D. stars has progressed to $7^h\,0^m - 68°$.

The results of a count of stars on the plates with centres along Dec. $-67°$ was forwarded to Professor H. H. Turner in October.

Magnetic Observations and Reductions.—The absolute value of the earth's magnetic field has been determined fortnightly throughout the year and the scale values of the Adie recording instruments at intervals. No curves have been measured, but the classification of the curves has been forwarded quarterly to De Bilt.

Money has at last been granted for the erection of a magnetic observatory on an undisturbed site, and the work has been placed in the hands of the Department of Public Works. The plans for the building were prepared some time ago, the building adopted being similar to those of the U.S. Coast and Geodetic Survey. The site chosen is at Toolangi, some thirty-five miles N.E. of Melbourne, and remote from any probable disturbance from electric traction for many years to come.

The means of the observed absolute values of the magnetic elements for the last three years are:—

	D.	H.	I.
1916	8° 6′·7 E	·22998	67° 48′·9
1917	8° 3′·2 E	·22961	67° 50′·9
1918	8° 2′·6 E	·22940	67° 51′·7

Seismograph.—The records have been read off and the results forwarded to Shide, as in the previous year.

Weights and Measures.—Through the courtesy of the Treasurer of Tasmania and the Minister for Lands of New South Wales, the copies Nos. 18 and 37 of the British Fundamental Yard and copies Nos. 11 and 30 of the British Fundamental Pound were brought to Melbourne and compared with the copies No. 40 (Yard) and No. 29 (Pound) in the possession of the Observatory and with the Victorian Primary Standards. The results are not yet completely reduced, but they leave no doubt that the Victorian Primary Standard Yard (No. 1383) is seriously in error.

The time-service, registration of tides, and various miscellaneous services have been continued as in 1917. At the request of Dr. Adams, of the Hector Observatory, a series of scientific time-signals were sent out through the Melbourne radio-station during the winter months, but his receiving apparatus did not permit him to make use of the signals. They were received on several evenings at the Adelaide Observatory.

Personal.—A further vacancy has occurred on the Observatory staff through the transfer of Mr. Cornell (astrograph observer) to another department. No vacancy at the Observatory has been filled for several years and no funds are available for temporary assistance of any description. No work on the reduction of the magnetic and tidal records can be undertaken, and the work of reduction of the meridian observations, and more particularly of the astrographic plates, can go on very slowly, owing to the very limited staff now available.

Notes on some Points connected with the Recent Progress of Astronomy.

Discovery of Minor Planets in 1918.

Fifty-five planets were discovered or first announced in 1918, as follows:—

Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.
	1918.			1918.			1918.	
BD 887	Jan. 3	W	DV	Aug. 1	W	EM	Sept. 13	P
DC 888	Feb. 2	,,	DW	1	,,	EN	Oct. 9	W
DD	2	,,	DX	1	,,	EO	29	,,
DE	4	,,	DY	1	,,	EP	29	,,
DG 889	Mar. 5	,,	DZ	3	,,	EQ	30	,,
DH	5	,,	EA	3	,,	ER	29	,,
DJ	8	,,	EB	3	,,	ES	30	S
DK 890	11	,,	EC	10	,,	ET	30	,,
DL	16	,,	ED	11	,,	EU	Nov. 12	W
DM	17	,,	EE			EV	22	,,
DN	17	,,	EF			EW	22	,,
DQ 891	May 17	,,	EG			EX	30	,,
DR 892	31	,,	EH			EY	Dec. 6	,,
DS 893	31	,,	EJ			Algiers D		
DT 894	June 4	,,	EK	Sept. 15	,,			
DU	July 11	,,	EL	15	,,			

The initials stand for:—

P = Dr. Palisa, Vienna.
S = Herr A. Schwassmann, Bergedorf, Hamburg.
W = Professor M. Wolf, Königstuhl Observatory, Heidelberg.

The following identities have been found: 1918 DO = 861: Simeis 1 = Simeis 75 = 1895 $B\theta$; 888 = 1915 XN, 889 = Transvaal 16, 890 = 1908 CX, 891 = Simeis 12, 894 = 1907 ZL = 1912 OV = Transvaal 3. 886 was discovered by Peters at Washington 1917 Nov. 16. Four planets discovered at Johannesburg in 1916 June, July were erroneously identified there with Nos. 296, 651, 806, 459 respectively: they are now designated 1916 *i*, *k*, *l*, *m*, and appear to be new except *l*, which is probably 715 Transvaalia. Four planets, 1916 *e* (Peters), *f*, *g*, *h* (Nicholson and Shapley), were

discovered in America, 1916 Apr., Sept., Oct., Oct. The last three were very faint; an orbit of *f* was given in *Ast. Jour.*, **30**, 127.

Planet 1917 *c* was discovered at Hamburg on 1917 Nov. 15.

Of the planets in last year's Report, CQ 884 has received the name Priamus, and proves to be a member of the Trojan group. 886 has been named Washingtonia. The following have been numbered: 7th Simeis planet = 877, 1916*f* = 878, CJ = 879, CK = 880, CL = 881, CM = 882, CP = 883, CQ = 884, CX = 885.

887 Alinda has a very interesting orbit (see *M.N.*, **78**, 447), with a perihelion distance about the same as those of 433 Eros and 719 Albert. It was very fully observed from Jan. 3 to May 3, so the orbit is much better known than that of Albert, of which only a very few observations were obtained. The elements of both planets are given for comparison, referred to the epoch and equinox 1925·0.

Planet.	*m*.	*g*.	M.	ω.	Ω.	*i*.	ϕ.	μ.	log *a*.
			°	°	°	°	°	″	
719	17·6	14·5	75·634	151·943	185·741	10·828	32·722	853·665	0·41248
887	17·1	14·1	264·390	347·804	110·980	8·960	32·229	880·158	0·40363

Since the period of 887 is roughly $\frac{1}{3}$ of Jupiter's, the perturbations by the latter will be considerable. There will be another favourable opposition early in 1922, when it should be possible to recover the planet. At the intermediate oppositions (1919 June 11 and 1920 August) its magnitude will be 19·0, so it is unlikely to be observed.

There are now five known members of the Trojan group; Achilles, Nestor, and Hector have longitude about 60° greater than that of Jupiter, while Patroclus and Priamus have longitude about 60° less. It is surprising that the plan was not followed of assigning the names of Greek heroes to planets on one side of Jupiter, and of Trojan heroes to those on the other, as it would have been an aid to memory. Several redeterminations of the orbits of the Trojan planets have been made during the year, and published in *Ast. Nach.*, etc.

Marseilles Observatory has done most useful work in distributing ephemerides and other information concerning minor planets in the form of Circulars. The *Journal des Observateurs* also devotes much space to them. It is a matter of regret that no accurate ephemerides of the four bright minor planets are now available, the *Nautical Almanac* having discontinued them, while those published by the Berlin Rechen-Institut are only approximate.

A. C. D. C.

Discovery of Comets in 1918.

Encke's Comet, discovered on 1917 December 30, passed its perihelion on 1918 March 24. It was well observed in the northern hemisphere in February and March, when it was quite a conspicuous telescopic object. Mr. Reid followed it in the southern hemisphere up till June. The elements were given in the last Report.

Wolf's Comet (*b* 1916) was observed up till 1918 January 29, on which date a photograph by Professor Wolf showed it as a small nebulous mass, of mag. 15, with a very faint nucleus. Dr. Holetschek determined its maximum brightness as 8·7 magnitude in 1917 mid-July. The elements were given in the last Report.

Faye's Comet was unsuccessfully searched for at Heidelberg and Bergedorf in February and March.

Comet 1918*a* was discovered by Mr. Reid at the Cape at 6 p.m. on June 12 in R.A. $9^h\ 16^m\ 36^s$, S. Decl. 8° 10′, daily motion 48′ due south. It was described as a faint round nebulosity. Mr. H. E. Wood gives the following orbit in Union Observatory Circ. 43, from Johannesburg observations on June 13, 16, 19 :—

$$T = 1918 \text{ June } 5{\cdot}275 \text{ G.M.T.}$$
$$\left.\begin{aligned} \omega &= 194^\circ\ 7'\ 18'' \\ \Omega &= 17\ 49\ 28 \\ i &= 70\ 8\ 41 \end{aligned}\right\} 1918{\cdot}0.$$
$$\log q = 0{\cdot}04194.$$

Comet 1918*b* is a return of Wolf's Periodic Comet. It was detected on July 9 by M. R. Jonckheere at the Royal Observatory, Greenwich; Professor Barnard found it independently three days later. It was then of mag. 15, but rose to the 11th on November 5, when Professor Wolf found it an easy object visually. A photograph showed a nucleus of mag. 12 eccentrically placed N.W. of the centre of the nebulosity, which was 2′ in diameter.

Comet 1918*c* is a return of Borrelly's Periodic Comet (1905 II. = 1911 VIII.). It was detected on August 7 by M. Fayet at Nice. The return was a favourable one, the distance from the earth in December being less than half a unit; the comet became quite an easy object, being observable with a 3-inch telescope. It was still under observation at the end of the year.

Comet 1918*d* was discovered on November 23 by Dr. Schorr at Bergedorf, Hamburg. It was of mag. 14 and growing fainter, having passed perihelion two months earlier. It proves to be a comet of short period, 6·7276 years, belonging to the Jupiter family; it was still under observation at the end of the year.

The following are the orbits of the comets 1918*b*, 1918*c*, 1918*d*. In the second, the value of T_π is corrected by the observations :—

Comet	Wolf.	Borrelly.	Schorr
Computer . . .	Kamensky.	Von Tolnay.	MM. Braae and Fischer-Petersen.
T in G.M.T.	1918 Dec. 13·391	1918 Nov. 16·60	1918 Sept. 27·5834
ω	172° 54′ 42″	352° 23′ 1″	278° 8′ 12″
Ω	206 41 32	77 1 48	117 56 28
i	25 17 32	30 29 29	5 35 16
ϕ	33 58 32	37 57 21	28 10 47
μ	522″·42893	513″·90816	527″·43
Equinox	1918·0	1925·0	1918·0

A. C. D. C.

Solar Activity in 1918.

Sun-spots.—The sun in 1918 showed no groups of spots at all approaching in size and interest the two giant groups of 1917, viz. those of 1917 February 4–15, and August 4–16. But if sun-spots may be classed, like the stars, according to "magnitudes," then, though there were no groups of the first magnitude in the year 1918, there were some of the second, and many of the third, and these, like the spot-groups of 1917, included several striking "processions" of groups following each other at short intervals along a parallel of solar latitude, and also some cases of "scattered disturbance," where a broad and extended area is sown, as it were, with small, half-developed spots without any orderly arrangement. The chief "processions" were seen May 3–13, July 3–9, and August 3–11, while at the end of May and beginning of June, no fewer than eight groups, arranged in four pairs of short "processions," appeared at the East limb. A fine example of a "scattered disturbance" passed across the disc July 17–28, and another July 26–August 6, and one of better developed spots October 18–29. But the species of formation most characteristic of the year was that of a "stream" of spots, sometimes so nearly continuous, at any rate during part of its history, as to differ but little from a single, very elongated, spot. Amongst these may be instanced the streams of January 18–26; January 22–29; February 11–22; March 8–20; March 31–April 11; July 19–30; August 10–23; September 17–29; September 26–October 5; October 11–23; November 11–23 and December 17–26. Few of these were quite of the "normal" type; *i.e.* two large spots connected by a row of small spots, all lying nearly on the same parallel of latitude.

E. W. M.

The Prominences.—A rapid decline in prominence activity occurred during 1918. The mean daily areas in square minutes of arc, derived from the Kodaikánal photographic records, are as follows:—

	North.	South.	Total.
1918 January to June . . .	2·28	2·72	5·00
July to December . . .	1·24	1·99	3·23

The mean daily number recorded also fell from 18·2 for the first six months to 16·1 for the second half of the year.

The high latitude prominences reached their greatest development in the southern hemisphere, and closest approach to the poles during the early months of the year, and then rapidly declined. After July there were no prominences of any magnitude recorded between latitude +50° and the north pole. In the south the polar regions maintained some slight activity until the end of the year. This decline of the polar prominences is a well-marked phase in the prominence cycle, and occurred last in the year 1907.

Prominences generally attained a maximum development in the northern hemisphere early in 1917, whilst the southern maximum occurred during the first half of 1918. This delayed action of the south has caused a reversal of the relative activity of north and south, as is seen on comparing the areas given above with those in the report for 1917.

Prominences projected on the disc as absorption markings attained their greatest development during the first six months of 1918 in both hemispheres, but there was a rapid decline during the latter half of the year in the northern hemisphere only.

Prominence areas east and west of the sun's axis show a western excess during the first half of the year and an eastern excess during the second half. The denser prominences appearing as absorption markings give the usual eastern excess throughout the year, the areas recorded east of the central meridian being 52·4 per cent. of the whole, derived from 5720 markings. Metallic prominences and prominences showing displaced lines were more frequent on the western limb than on the eastern.

The usual excess of displacements towards red is indicated for the hydrogen lines both at the limb and on the disc. J. E.

Solar Research in 1918.

The Solar Spectrum. — Further studies of electric-furnace spectra have been made at the Mount Wilson Laboratory by A. S. King (*Ap. J.*, **48**, 13). In the case of barium it was found that besides being sharper than in the arc, some of the diffuse arc lines were resolved into two or three components, and there is evidence that these resolved lines occur as absorption lines in the solar spectrum. The observations suggest that in the sun these lines are produced in a region of moderately high temperature in combination with low-pressure conditions.

Group P, about λ 3360, in the ultra-violet region of the solar spectrum, has been found by A. Fowler and C. C. L. Gregory to be chiefly due to absorption by ammonia in the atmosphere of the sun (*Proc. Roy. Soc.*, A, **94**, 470). Of 260 band lines of ammonia in the region 3450 to 3286 A, there are 140 which correspond with previously unidentified faint solar lines, the remainder being mostly obscured by lines of metallic origin. In a companion investigation (*Proc. Roy. Soc.*, A, **94**, 472), Professor Fowler has found that the band of luminous water vapour about λ 3064 is also represented by faint lines in the solar spectrum. Of 257 measured lines composing this band, at least 150 correspond with Fraunhofer lines for which no other origins have been suggested.

Direct photographic records of the solar spectrum extending into the infra-red as far as λ 9600 A have been obtained by W. F. Meggers, of the Washington Bureau of Standards, by the use of plates stained with dicyanin (*Ap. J.*, **47**, 1). A grating spectrograph was used, and wave-lengths comparable in accuracy with

those of Rowland are obtainable. Photographs of numerous metallic arc spectra have led to the identification of nearly 400 of the solar lines not previously tabulated. The telluric lines which fall in the region are under investigation at the Allegheny Observatory by the solar rotation method.

In another paper (*Sc. Papers Bur. Stand.*, Wash., No. 324) Messrs. Meggers and Kiess give tables of the wave-lengths of the infra-red arc lines of iron, nickel, and cobalt, extending as far as λ 11,000 A. An interesting by-product of the investigation is the discovery that the oxygen triplet at 7771–7775 A, which is present in the solar spectrum, occurs in several metallic arc spectra when observed in air. Another strong line of oxygen at 8466·2 A was also found in some of the metallic arcs, and this also appears as an absorption line in the solar spectrum.

A further test of the theory of relativity has been made by J. Evershed in an investigation of the displacements of cyanogen band lines in the solar spectrum, based upon direct comparisons with corresponding lines in the carbon arc (*The Observatory*, **41**, 371). The measured displacements were somewhat greater than those obtained at Mount Wilson by St. John, but were still not much more than half the predicted amount. In the case of iron lines, the displacements at the limb were in many cases twice as great as those predicted by the theory, and Mr. Evershed suggests that an explanation of these may be found in the unsymmetrical shading towards the red of most of the Fraunhofer lines, the effect being greatest at the limb because of the greater depth of the absorbing vapour.

Additional evidence on this question is afforded by Mr. Evershed's investigations of the spectrum of the planet Venus (*The Observatory*, **42**, 51). These show that the general displacement of the solar lines towards the red only occurs on the side of the sun which faces the earth, whereas a gravitational effect would be constant all over the sun.

Solar Magnetism.—An account of further extensive investigations of the general magnetic field of the sun has been given by Messrs. Hale, Seares, Van Maanen, and Ellerman (*Ap. J.*, **47**, 206). By the use of suitable polarising apparatus, one component of the modified lines due to the magnetic field was suppressed, and the measurements were thus reduced to determinations of the displacement of the other component. These displacements are so small that their reality was only established after much labour, notwithstanding the very large scale of the spectra utilised. Twenty-six lines in addition to those recognised in the earlier observations were found to give measurable displacements, and that the sun behaves as a uniformly magnetised sphere, with a polarity corresponding with that of the earth, is now considered beyond reasonable doubt. The deduced strength of field at the pole varies to some extent with line-intensity, and ranges from 9·9 to 54·7 Gaussian units Adopting St. John's conclusion that the stronger lines represent higher levels, it would appear that the

strength of the field falls off very rapidly on receding from the photosphere.

The work of Hale on the position of the Sun's magnetic axis has also been extended by Messrs. Seares, Van Maanen, and Ellerman (*Proc. Nat. Acad. Wash.*, 4, No. 1). The axis was found to be inclined to the axis of rotation at an angle of about 6°, and to revolve about the axis of rotation in 32 days.

An important new departure at Mount Wilson is the institution of daily visual observations of the magnetic polarities of sun-spots (*Mount Wilson Report for* 1917). The observations are made with the 75-ft. spectrograph, and during 1917 the polarities of an average number of 40 spots were determined on each day of observation. The strength of the field was also determined in numerous cases. In double spots the two members have been found to be of opposite magnetic polarity; the preceding members in the northern and southern hemispheres are also of opposite polarity, indicating a reversal of the vortex in the two cases. After the sun-spot minimum of 1912, the polarities of preceding spots in a given hemisphere were opposite in sign to those previously observed, and the polarities thus seem to be intimately connected with the cause of the sun-spot cycle.

Solar Radiation.—The observations of Abbot on the radiation from different parts of the sun's disc have been utilised by Professor Shin Hirayama in a determination of the transmission and radiation of the solar atmosphere, on Schuster's supposition that there is an absorbing and radiating layer above the photosphere (*Proc. Tokyo Math.-Phys. Soc.*, ser. 2, 9, 236). The radiation due to the atmosphere is found to range from one-third of the total radiation for the shorter wave-lengths to nearly one-half for the greater wave-lengths. Assuming the effective solar temperature to be 6000° Abs, the temperature of the absorbing layer is calculated to be 5210°, and that of the photosphere 7040°.

In continuation of the work of Clayton, C. G. Abbot finds that there is no well-marked periodicity of solar radiation which persists throughout the whole period of observation, extending from 1908 to 1916 (*Smiths. Misc. Coll.*, 69, No. 6). In 1915, however, a period of about 27 days was strongly shown, suggesting that one side of the sun radiated with greater intensity than the other during several rotations. During 1916 there were indications of a periodicity of about $3\frac{1}{2}$ days.

A new observing station for investigations of solar radiation has been established, under the direction of Dr. Abbot, at Calama, Chile, by the Smithsonian Institution (*Pop. Ast.*, 26, 633). The site is 2250 metres above sea-level, and is said to be the most cloudless in the world.

The Sun's Rotation.—The possible effects of light scattered by atmospheric haze upon spectroscopic determinations of the sun's rotation period have been further discussed by R. de Lury (*Ap. J.*, 48, 195). It is concluded that the higher values deduced by some observers were obtained during brighter conditions, and low values

during hazier conditions. Mr. de Lury is of opinion that there is at present no sound reason for believing the rotation period to be variable. In another paper (*Jour. R.A.S. Canada*, 12, 437) the same author estimates that a drop of 6 per cent. from the average intensity of solar radiation, such as might follow a great volcanic eruption, is accompanied by a reduction of 3 per cent. in spectroscopic measurements of the rate of rotation at the sun's equator.

Miscellaneous.—As a result of his own observations of the phenomena, Mr. A. A. Buss considers that the "solar hydrogen bombs" described by Ellerman represent appearances on the sun's disc of the brilliant spikes which an active area invariably exhibits when passing over the limb (*Nature*, **101**, 5).

A brief outline of the Mount Wilson observations bearing upon the question of the nature of sun-spots is given by Professor Hale in *Proc. Roy. Soc.*, A, **95**, 234.

Numerical data showing the varying frequency of calcium flocculi, as photographed at the Madrid Observatory since April 1912, are given in the *Anuario* of that observatory for 1918. Measures of calcium flocculi have also been regularly given by Father Cirera in the monthly publications of the Observatorio del Ebro.

In a paper on the astronomical phenomena which may be dependent on the scattering of light by gaseous molecules, Professor Ch. Fabry suggests that the part of the luminosity of the corona which gives a continuous spectrum may be due to such scattering, and not to reflection by small particles (*The Observatory*, **41**, 211). It is estimated that a truly gaseous corona having a density only one-thousand-millionth that of air at atmospheric pressure would scatter sufficient light from the photosphere to account for the luminosity of the corona, and for the polarisation effects which have been observed.

The scattering and polarisation of light by gases has been studied experimentally by R. J. Strutt (*Proc. Roy. Soc.*, A, **94**, 453, and A, **95**, 155). A. F.

Total Solar Eclipses.

1911 *April* 28.—The results of measurements of a photograph of the spectrum of the chromosphere and corona which was obtained with a prismatic camera at Vavau, Tonga Islands, during this eclipse have been given by Father Cortie (*M.N.*, **78**, 441). The spectrum extends far into the red, and 25 previously unrecorded lines are assigned to the chromosphere in the region 6600 to 7640 A. There were also indications of a new coronal radiation about 7150 A, which may be associated with the known line 5535·8 A in accordance with the theoretical work of Nicholson.

1914 *August* 21.—A photograph of the spectrum of the corona taken during this eclipse, at Hernösand, Sweden, has also recently been measured by Father Cortie (*M.N.*, **78**, 665). The wave-

lengths of 36 faint lines between 4780 and 6616 A are given, and 24 of these do not appear in any previous records.

Interesting details of pyrheliometric observations made during this eclipse have been given by L. Palazzo in *Mem. Soc. Spett. Ital.*, 7, series II., 67.

1918 *June* 8.—This eclipse was visible in the United States, along a belt extending from the State of Washington to Florida. Owing to the war, there were no British expeditions, but the eclipse was observed by numerous parties of American astronomers. Cloudy skies appear to have been very general along the path of totality, but several of the observers were favoured by complete or partial breaks in the clouds at the critical moments, and valuable results were in many cases obtained.

An expedition from the Lick Observatory, under the direction of Professor Campbell, was stationed at Goldendale, in the State of Washington, and was especially successful in carrying out an extensive programme of observations (*Pub. Ast. Soc. Pac.*, 30, 219). Some particularly fine photographs of the corona were obtained with a lens of 6 inches aperture and 40 feet focal length, which was pointed directly at the sun. Arches of coronal matter surrounding all the principal prominences are a striking feature of these photographs, and there can be no doubt that the coronal structure is strongly influenced by the forces which produce the prominences. Stars as faint as the 8th magnitude appear on photographs taken with other instruments, and it is hoped that the measurement of these may give results bearing upon the predicted displacement of stars due to the gravitational field of the sun. Five well-known corona lines, at wave-lengths 3601, 3987, 4086, 4231, and 5303, appear on a plate taken with a single-prism spectrograph, and seven other bright lines are suspected. Another plate was taken with a 3-prism spectrograph for the determination of the position of the green line, and a preliminary measurement has shown that the wave-length differs very little from 5303·0 A. The coronal spectrum was only recorded as far as 6′ or 7′ from the sun's limb, and, as on previous occasions, the Fraunhofer lines did not appear in this region. Among numerous other observations, Professor E. P. Lewis recorded strong polarisation of the light of the corona to a distance greater than the sun's diameter.

A further account of the spectroscopic and polariscopic results is given in *L.O.B.*, No. 317. Professor Lewis, who employed a quartz spectrograph, gives the following lines as belonging without doubt to the spectrum of the corona :—

3330 Very faint.	3802 Faint.
3360 Faint.	3988 Faint.
3387 Fair.	4087 Very faint.
3455 Faint.	4230 Very faint.
3602 Fair.	5303 Faint.

For the green line, Messrs. Campbell and Moore found the wave-length 5302·98, as expressed on the scale of Rowland.

Preliminary accounts of the work of the expedition from the Yerkes Observatory, and of several other observing parties, are given in *Pop. Ast.*, 26, No. 7. At Green River, Wyoming, where the Yerkes observers were stationed, Professor Barnard obtained excellent pictures of the corona with a 6-inch lens of 60 feet focal length, but thin clouds prevented Professor Frost obtaining completely successful results with his extensive spectroscopic equipment. Some hundreds of interesting spectra, however, were obtained with a moving-picture camera, in which the ordinary lens was replaced by an objective prism and a lens of 40 cm. focal length; the exposures were made near the beginning and end of totality, at the rate of 16 per second, and the photographs thus show the progressive changes of spectrum as the chromosphere was traversed by the moon.

Some of the Mount Wilson observers were also stationed at Green River. Mr. Ellerman secured a photograph of the corona with an 8-inch objective of 30 feet focal length, and spectroscopic observations by Dr. St. John were partially successful. A special effort was made to determine the precise wave-length of the green line at opposite limbs of the sun, but the west limb was unfortunately obscured by clouds; at the east limb, the deduced wave-length was 5303·204 on Rowland's scale, giving 5303·239 when corrected for displacement due to the sun's rotation.

Excellent results also appear to have been obtained by the Lowell Observatory Expedition, under Dr. V. M. Slipher, which was located near Syracuse, Kansas. In addition to the continuous spectrum and emission lines of the inner corona, a small dispersion photograph shows the Fraunhofer lines in the spectrum of the outer corona.

The general form of the corona was intermediate between the maximum and minimum types.

1919 *May* 29.—The total eclipse of next May will be visible along a belt extending from near the Pacific Coast, across northern Brazil, and across Africa from a point near Libreville, by way of Lake Tanganyika. The Joint Permanent Eclipse Committee has made arrangements for two expeditions, one to Brazil, and the other to the island of Principe, near the West Coast of Africa. The location of the sun among comparatively bright stars at this eclipse provides a specially favourable opportunity for testing the deflection of rays of light by the sun's gravitational field which is predicted by the theory of relativity, and the work of the observers will be mainly concentrated on this important problem. The maximum duration of totality on the central line will be six minutes fifty seconds.

A. F.

Nova Aquilæ III. (1918).

The discovery of the brilliant new star in Aquila, R.A. $18^h\ 44^m\ 43^s$; Dec. $+0°\ 29'\ 30''$, 1918, was made independently by a great number of observers. In England the earliest observations

were made on June 8 by Miss Grace Cook (9·30, G.M.T.), Mr. W. F. Denning (10·0), Mr. D. Packer (10·0), Mr. C. L. Brook (10·15), Mr. W. H. Steavenson (10·30), Mr. F. de Roy (10·45), Mr. H. Thomson (11·44) (*Nature*, **101**, 105; *M.N.*, **78**, 569 *et seq.*, *Jour. B.A.A.* **28**, 207). These observers recognised the star as a newcomer, and at once made their observations known. The news was sent out by the Astronomer Royal on June 9. Thus observers in this country had early warning of the outburst, and are under obligations to amateur astronomers for their alertness. Similarly in America Mr. Cudworth's prompt notification of his recognition of the Nova enabled the Harvard observers to photograph the star on June 8 (*Harv. Bull.*, 658). Again, in France the Nova was recognised on June 8 by Professor Moye at Montpellier, and by M. Luizet at Lyons. Yet again in India Mr. G. N. Bower saw the new star on June 8, and at once made his discovery known (*Nat.*, **102**, 105). Professor Barnard found the Nova on June 8 on the evening after the total eclipse of the sun, which he observed at Green River, Wyoming (*Pop. Ast.*, **26**, 684). His alertness in observation enabled Professor Frost and Mr. Parkhurst to get photographs of the spectrum with the objective prism camera still in adjustment after the eclipse observations, probably the earliest spectrographic record obtained (*Pop. Ast.*, **26**, 698). Mr. Joy found the Nova on June 8 at Mount Wilson, and photographs of the spectrum were secured the same night. The unremitting character of the watch kept on the sky is well exemplified by the vast number of independent discoveries of the new star in all parts of the globe.

Examination of records obtained before the date of recognition of the Nova shows that a star of about eleventh magnitude is recorded on 406 plates at Harvard College Observatory, and on 54 of Professor Barnard's photographs. In the Harvard Circulars 208 and 210, issued by Professor E. C. Pickering, whose recent death is mourned by all astronomers, the outstanding facts are summarised. "The first record of Nova Aquilæ No. 3 is on a photograph taken here on 1888 May 22. The photographic magnitude was then 10·5. It was found on 405 subsequent photographs, extending to 1918 June 3, to be of nearly the same brightness. It underwent small but undoubted changes in light, becoming somewhat fainter in 1909. It also appears in the Algiers zone on 1892 August 12 and 1895 June 26, and on 54 photographs taken by Professor Barnard, the first being on 1892 June 29. 1918 June 4, 5, and 6 were cloudy here, but three photographs were obtained on 1918 June 7, when it was of the sixth magnitude. The following night, when its visual magnitude was 0·8, it was discovered independently by a large number of persons."

From Professor Barnard (*Pop. Ast.*, **26**, 559) we learn that Dr. Max Wolf at Heidelberg made two photographs of the region of the Nova on June 5, $9^h\ 44^m$ to $13^h\ 4^m$ G.M.T., which show the star in its normal condition of 10·5 magnitude. From *H.C.O. Circular*, No. 210, it appears that on the photographs of June 7

the magnitude was 6·7 at G.M.T. $18^h\ 20^m$, and it was 6·2 at $18^h\ 50^m$. At this rate of $\delta m/\delta t$ the magnitude of the star would have been 1·0 at about G.M.T. noon on June 8. It is of interest to note that an observer, Mrs. Thomas, at Corowa, New South Wales, is reported, after the recognition of the Nova, to have seen it bright on June 8 at G.M.T. noon (*Observatory*, **41**, 352).

Early observations on June 7 are claimed by Messrs. Luyten, Breson, Longbottom, Laskovski, Kacz, Piper. In the light of the evidence afforded by the photographs taken on June 5 and at Harvard on June 7, it is difficult to account for these observations without admitting the possibility of several alternatives, an error in identification or an error in date, or a considerable fluctuation of brightness such as has not been before noted in the earliest stages of a Nova. Professor Barnard discusses the question in an article in *Popular Astronomy*, **26**, 558, and Professor E. C. Pickering deals with it in *Harvard Circular*, No. 210.

Light-curves compiled from very numerous observations are given in *Harv. Circ.*, No. 208, to July 22; *Jour. B.A.A.*, **28**, 238, to July 23; *Pop. Ast.*, **26**, 496, to July 20. Mr. Hollis gives a valuable set of photometric observations at Greenwich in *M.N.*, **79**, 36, to November 7, when the photographic magnitude was 5·77. Other observations are recorded by Mr. Conroy, by Mr. Watson, and by Mr. Pocock (*M.N.*, **79**, 37–43). Dr. Rambaut gives the results of observations at the Radcliffe Observatory, together with an interesting diagrammatic comparison of the light curves of Nova Aquilæ and Nova Persei, 1901 (*M.N.*, **79**, 108).

As to the early phases of brightness, the main features may be broadly summarised as follows:—

1918.	G.M.T. h m	Mag.	
June 5	13	10·5	Heidelberg photographs.
7	18 20	6·7	Harvard photographs.
	18 50	6·2	
8	9 0	0·8	Visual observations *passim*.
9	...	−1	Maximum brightness, a whole magnitude brighter than Nova Persei (1901).
10	...	0	
20	...	2·2	
30	...	3·5	With slow fluctuations of semi-amplitude possibly as much as half a magnitude, and a possible period of 10–20 days.
July 30	...	4·5	
Aug. 29	...	5·0	
Sept. 28	...	5·5	
Oct. 28	...	5·6	

Maps (M) or photographs (P) of the field of the Nova are given as follows: *Harv. Circ.*, No. 208 (M); *Harv. Circ.*, No. 210 (P); *Pop. Ast.*, 26, 490 (M); *ibid.* p. 560 (Barnard, P).

Positions are given for the star by the Astronomer Royal from

Mr. Wichell's transit observations (*Nat.*, **101**, 285); by Mr. Aitken (*Pub.A.S.P.*, **30**, 256); by Mr. Burton and Mr. Hill (*Ast. Jour.*, **31**, 164), and by Mr. Pocock (*M.N.*, **79**, 43).

The Spectrum of Nova Aquilæ III. (1918).—The early recognition of the Nova before it had attained its maximum brightness has enabled spectroscopists in all parts of the globe to study the early phases with a degree of success which has never been equalled. The earliest photographic records taken on June 8 and 9 show that the first spectroscopic symptoms of the Nova were hardly distinguishable from those of a star of type A 2, except by the displacement of the absorption lines by about 20 tenth-metres towards the violet, the absorption lines of the Balmer series of hydrogen lines being strongly marked. The magnesium line at wave-length 4481 is also visible, similarly displaced. The calcium lines H and K are similarly displaced in a broad condition, but they are also represented by narrow absorption lines which are but slightly displaced from their normal position towards the violet.

By June 10 the characteristic features of the Nova spectrum were definitely established. The pairs of absorption and emission lines were marked features, and a large number of relatively narrow absorption lines had made their appearance in the spectrum. These narrow lines have been recognised by many observers as enhanced lines of Fe, Ti, Ca, Cr, affected by a displacement similar to those of the hydrogen lines. The enhanced lines of iron were accompanied by emission lines. On June 10 and the following days it became clear that the hydrogen absorption lines were double or even triple, as in the case of Nova Geminorum II., and the narrower lines became lost or diffuse. And in general the emission lines became an outstanding feature, in consequence of the fading of the continuous spectrum.

By June 20 the bright nebular lines began to assert themselves, and the bright bands near 4640 became prominent.

Then followed an interval in which these features continued prominent though affected by changes in detail, which may be expected to throw light upon the nature of the outburst.

The preceding paragraphs give a general summary of the phenomena, and, apart from the dates, they might be read as referring to any Nova. Certain features have been recorded in the case of Nova Aquilæ III. which are of special interest, and may now be referred to.

Professor Frost and Mr. Parkhurst were able to use their Zeiss UV doublet and 30° UV objective prism at Green River, Wyoming, after the solar eclipse in obtaining photographs of the spectrum of the Nova in rapid succession on the nights of June 8, 9, and 10. They have circulated prints of some of the spectra, and results of great interest may be expected from their examination of the changes in these earliest phases. Meanwhile, we may say that the prints show that marked changes occurred in the ultra-violet part of the spectrum between June 8 and 9 and again on June 10,

due apparently, as Mr. C. P. Butler has pointed out (*Jour. B.A.A.*, 29, 56), to the outburst of groups of absorption lines such as are prominent also in the solar spectrum. Careful examination should show whether, as appears to be the case from a cursory study of the prints, these lines share the displacement of the hydrogen absorption lines. If so, we have a very curious feature in the spectrum of the Nova on June 10, namely, that the region between H_ϵ and H_β exhibits the narrow lines characteristic of the spectrum of α Cygni, whilst the region in the ultra-violet has taken on some of the characteristics of stars of solar type.

Many observers, viz. Messrs. Adams and Joy (*Pub.A.S.P.*, 30, 251), Dr. Plaskett (*Jour. R.A.S. Can.*, 1918, 350), Mr. Lunt (*Nat.*, 102, 194), Mr. G. F. Paddock (*Pub.A.S.P.*, 30, 244), agree in recognising that in the spectrum of Nova Aquilæ III. many of the narrow absorption lines are displaced replicas of the characteristic lines of α Cygni. This feature was established by Professor Newall and Mr. Stratton in the case of Nova Geminorum II. (*M.N.*, 73, 380); and Professor Newall has shown in regard to Nova Aquilæ III. on June 13, that the characteristic lines of α Cygni are duplicated by two displacements corresponding with those of the absorption lines of hydrogen in the Nova on that date (*M.N.*, 79, 31). The fact that these narrow absorption lines are displaced by amounts equal to those of the hydrogen absorption lines makes it probable that the latter lines are seen in their entirety, and are not masked in part by the encroachment of the emission lines, as was at one time suggested.

It appears that the displacements of all of these absorption lines are approximately proportional to the wave-lengths. This criterion has hitherto been taken as a sign that such displacements are due to velocity in the line of sight; but the high velocities indicated by displacements of the order of 20 and 30 tenth metres —maintained as they appear to be for months—raise doubts as to whether there may not be other causes of unrecognised nature at work that may give rise to the observed effects.

If the displacements are interpreted as being due to velocity, then in the case of Nova Aquilæ III. there are marked indications of accelerations in the early phases, reminding one, as Mr. Evershed points out (*Nat.*, 102, 105) of the similar phenomena exhibited by eruptive solar prominences, though it is not yet clear whether the accelerations in the Nova are positive or negative.

From the wealth of observational data obtained, we may expect a great advance in our understanding of the outburst of a Nova. There are many visual observations of the spectrum, such as those made by Professor Fowler and Mr. H. Thomson and others, and published from time to time in *Nature*, vols. 101 and 102; and these may prove to be of considerable value when interpreted by reference to the photographic records which give more trustworthy estimates of wave-lengths.

An interesting set of seven spectrograms, taken with a prismatic camera by Mr. Butterworth (*Jour. B.A.A.*, 28, 246), shows very

well the great changes in the spectrum between June 11 and June 29. Dr. Iniguez gives in the *Anuario del Obs. de Madrid*, 1919, a full summary of observations made at Madrid, and illustrates it with reproductions of 55 spectrograms taken between 1918 June 9 and September 4. H. F. N.

Variable Stars.

A large amount of work on variable stars has been accomplished despite the many calls of the war; and if 1918 saw no very notable advance in theory or new methods, materials for future discussion are being steadily accumulated.

Amongst the more important publications of the year, special mention must be made of the appearance of the "Eighth Report of the Variable Star Section of the British Astronomical Association" (*Mem. B.A.A.*, 22). This report, which has been compiled by C. L. Brook, Director of the section, contains about 16,000 observations of 29 long-period variables in the five years 1910–14. There is a very suggestive introduction to the volume by H. H. Turner.

Another notable work completed during 1918 is the editing and publishing of "Baxendell's Observations of Variable Stars," by H. H. Turner and Miss M. A. Blagg. A concluding note by the former editor follows, summarising the results obtained. Of the 31 stars discussed, 7 are irregularly variable, while in the case of 10 others, though they are known to be fairly regular, the completed light curves could not be determined, since Baxendell was unable to follow the stars through their minimum phase. Of the remaining 14 long-period variables, 9 are found to belong to Group I. in Phillips's classification (*Jour. B.A.A.*, 26, 2), and 4 to Group II. Only 1 star stands outside both groups, and of this the observations are not very numerous. The editing of these observations has been spread over several years, and an interesting point which has emerged in the course of their publication is the change of view of both editors as regards the validity of the Argelander-Chandler terms in the elements. Starting with a belief in such periodic terms, they have been faced with their breakdown when these early observations are compared with those of recent date. That there are changes of some kind is in many instances indisputable, and the alternative hypothesis is put forward tentatively, as worthy of trial, that the light changes sometimes exhibit sharp discontinuities or abrupt changes of period.

Amongst the irregular variables, the light curves of R Scuti and R Sagittæ, and in a less degree S Vulpeculæ, have been found to exhibit striking similarities, and some very interesting results have been obtained.

The whole of the work, extending, as it does, to an aggregate of over 300 pages of the *Monthly Notices*, has involved a great deal of careful and patient labour. Many difficulties, *e.g.* those connected with the correct identification of comparison stars, etc.,

had to be overcome, and it is stated in the concluding note that the greater part of the work has been carried through by Miss Blagg. The arrangement, discussion, and presentation in convenient form of these early observations is an extremely valuable contribution to our store of variable star information.

A paper of much theoretical interest is published by A. S. Eddington in *M.N.*, 79, 2. It is part i. of a mathematical inquiry into "the Pulsations of a Gaseous Star and the Problem of the Cepheid Variables." In the type of pulsation assumed the star remains spherical, though an elliptical deformation is also possible. In a table of 14 stars are given, amongst other data, the absolute magnitudes (which it is known are correlated to the periods and are deduced from them), the temperatures inferred from the spectral types, the calculated radii, and the amplitudes of the pulsations. A second table contains, amongst other things, the masses derived from the theory of radiative equilibrium (*M.N.*, 77, 16, 596), and the central density, which is 54 times the mean density. For all but two of the 14 stars the maximum central density is less than 0·1, from which it may be inferred that as a class the Cepheids are truly gaseous stars. On calculating the separation of the companion on the assumption that the Cepheids are binaries, it is found that in nearly every instance the secondary is within the boundary of the principal star: a result which (as already remarked by Shapley) seems fatal to the binary hypothesis. Concerning the maintenance of the pulsations, it had been found (*M.N.*, 77, 16) that the difficulties were partly removed by the very great opacity of the stars, which must render the vibrations near the centre approximately adiabatic. The stars are accordingly largely heat-tight, and the dissipation of energy considerably less than at first seemed probable. Investigating the case of a star of assumed mass and density, and applying the results to δ Cephei as the typical star, the author finds satisfactory agreement between the calculated and observed period. In the latter part of the paper it is pointed out that accurate observations of change in the periods of the Cepheids, by providing a means of measuring a very slight change of density, would go far towards determining the rate of stellar evolution and the length of life of a star.

In *M.N.*, 78, 185, Rev. T. E. R. Phillips gives the results of analysing the light curves of the 18 short-period variables in Pickering's Class IV. (*H.A.*, 46). He finds some evidence that these stars also fall into two divisions similar to those in which the long-period variables are grouped. The number of stars placed in the first division (from which, however, β Lyræ should probably be excluded as a binary) is only 5, but the second division is well marked and contains the remaining 13 stars. Messrs. Martin and Plummer had already found the stars observed at Dunsink to exhibit the features characteristic of Group II. among the long-period variables, and a paper by them in *M.N.*, 78, 640, on the short-period variable RS Bootis, adds yet another.

The similarity of behaviour exhibited by the long- and short-

period variables (other than eclipsing stars) perhaps points to some common cause operating at a certain stage of evolution independently of conditions which determine the period. Whether the observed variations in light and radial motion are to be attributed to pulsations in single bodies may still be debated, and J. H. Jeans, in the discussions at meetings of the Society, has raised certain objections against the theory (*Observatory*, **41**, 78 and 434), but probably there are very few who now suppose the stars to be binary systems. It seems as if the changes must arise from some action within the stars themselves.

In *M.N.*, **78**, 639, F. A. Lindemann suggests a method of testing the pulsation theory of the Cepheids based on observations of the spectral lines. Should the theory be confirmed, the method will also give the parallaxes of the stars.

In *Ap. J.*, **48**, 4, there is another paper on RS Bootis, the authors being F. H. Sears and Harlow Shapley. The star belongs to the cluster type, now generally classed with the Cepheids, and shows similar colour changes. Two sets of observations, made with different instruments and separated by an interval of some years, are compared, and revised light- and colour-curves and elements derived. A spectroscopic investigation by Pease shows the changes in spectral type to be in good accord with those deduced from the accepted relation between colour index and spectrum. It is also shown that the colour of this and other Cepheids is more closely connected with the characteristics of the hydrogen lines than with certain other spectral phenomena.

In addition to the papers in *M.N.* above mentioned, vol. lxxviii. contains the following:—

Observations and deduced elements, by A. S. Williams, of a star in Auriga discovered by him to be variable several years ago. It is of the Cepheid type (p. 483).

"Sir William Herschel's Observations of Variable Stars and Stars suspected of Variability." They were collected and copied by Caroline Herschel from the original Journal or Review, and have only lately been found, and communicated to the Society by J. L. E. Dreyer (**78**, 554).

"A Discussion of the Dunsink Observations of the Eclipsing Variable W Ursæ Minoris," by C. Martin and H. C. Plummer (**78**, 644).

The *Journal of the British Astronomical Association* contains the report of C. Grover's observations of long-period variables at the Rousdon Observatory (**28**, 70), and reports Nos. 22, 23, and 24 of the variable star section of the Association (**28**, 111, 182, and 209).

No. 22 gives the results of the work on SS Cygni in 1917. Seven maxima were recorded, and on the whole the star's variations were less irregular than in 1916.

No. 23 gives an account of the three irregular variables R Coronæ, U Geminorum, and R Scuti in 1916 and 1917, with light-curves. Between 1917 April 27 and May 8 the decrease in

light of R Coronæ was very nearly half a magnitude a day, recalling the fall of 1905 April–May, but in 1917 the minimum lasted nearly a month instead of a few days.

No. 24 deals with the observations of 38 long-period variables.

In *Circular* 42 *of the Union Observatory, South Africa*, are published the results of visual and photographic observations of a number of long-period variables covering in some cases more than 20 years. The dates of maxima and minima, together with the light-curves and deduced elements, are given for several of the stars, and the results compared with those obtained elsewhere.

The "Monthly Reports of the American Association of Variable Star Observers" have been published as heretofore in *Popular Astronomy*. The report in 26, p. 268, contains a reference to Paul S. Yendell, who died on 1918 February 6 at the age of 73. He had been an enthusiastic observer for many years, and contributed numerous articles to the *Astronomical Journal* and *Popular Astronomy*.

The *Publications of the American Astronomical Society* contain papers by H. Shapley, F. C. Jordan, S. D. Townley, Z. Daniel, S. I. Bailey, R. S. Dugan, J. Kunz, Joel Stebbins, S. Albrecht, Miss Leavitt, and Miss Cannon dealing with the discovery, observations, and elements of variable stars of all classes. H. N. Russell points out (p. 14) that the attempt to explain the changes in light of the Cepheid variables by the rotation of unequally luminous globes may be tested by harmonic analysis.

In *A.N.*, 4965, W. Dziewulski compares two sets of observations of the eclipsing star U Herculis by J. Plassmann between 1895 and 1918, with observations of the same star by J. F. J. Schmidt made more than 30 years earlier. He finds that no change in the period can be established.

Journal des Observateurs, vol. ii., contains W. Doberck's observations of several variables (Nos. 4 and 11), and a summary by F. de Roy of his observations in 1916 of 34 long-period variables.

Other papers dealing with observations of variable stars and their discussion will be found in *Jour. R.A.S. Canada* (12, 56); *Ap. J.* (47, 46); *Ast. Nach.* (4951, 4954, 4955, and 4963); *H.C.O. Circular*, 207; *Mem. Soc. Spett. Ital.*, 7, serie 2ª; *L'Astronomie* for 1918, pp. 128, 348 (summary of observations and light-curves of Mira Ceti in 1916–17, by various observers), and 464 (discovery of a new variable by J. Ellsworth). T. E. R. P.

Double Stars.

New Pairs.—During the year 1918 particulars of 212 new double stars under 5″ separation have been published.

The largest list was contributed by R. G. Aitken (*L.O.B.*, No. 306); it contains 100 new pairs from A 2901 to A 3000, thus bringing his total to a figure which is far above that of any other double-star discoverer. Most of the stars of the present list are

exceedingly difficult objects, whose duplicity had been suspected during Aitken's great survey, commenced in 1899. A list of 43 of these pairs had already been published, being designated A 29 .., in *Memoirs R.A.S.*, 61, the data having been kindly communicated by Professor Aitken before their publication by the Lick Observatory.

T. E. Espin (*M.N.*, 78, 193) publishes details of 77 new pairs under 5″ separation, and 38 over that limit. These stars are situated between declination 39° and 41°. They were discovered with a 24-inch Calver reflector, and bring Mr. Espin's total to 1705, about half of which are under 5″.

The same paper contains 35 new pairs found by Mr. W. Milburn, who is using the 17¼-inch previously used by Mr. Espin. These stars are mostly between ·5″ and 10″ separation, but 8 are under the 5″ limit. Errata to these two lists are given by E. Doolittle in *M.N.*, 78, 690.

F. C. Leonard has published particulars of 31 new pairs, all of which are well under 5″ (*M.N.*, 78, 475). Most of these were discovered with the 12-inch refractor of the Yerkes Observatory.

E. D. Roe found 6 pairs under 5″, and 4 over 5″, with the 20-inch refractor of the Chamberlin Observatory and a 6½-inch refractor (*A.J.*, No. 739). The stars are numbered from Roe 95 to 114, but some of these had been previously announced in *Ast. Nach.*, 4874.

In the *Pub. del Obs. Ast. de La Plata*, vol. iv. part i., B. H. Dawson gives a list of 30 new pairs found in the southern hemisphere with the 17-inch refractor by Professor Hussey and himself. Of these stars, 22 are under 5″ separation.

C. P. Olivier has announced the discovery of 11 new double stars, all of which are under the 5″ limit of separation (*A.J.*, No. 733). These were found with the 26-inch refractor of the Leander McCormick Observatory.

Measures.—The largest publication of double star measures which appeared in 1918 forms vol. iv. part i. of the *Pub. del Obs. Ast. de La Plata*. This is a valuable work of 144 quarto pages, containing measures of about 1400 stars. The observations were made from 1912 to 1917 by B. H. Dawson, using the 17-inch Gauthier refractor of the La Plata Observatory. The volume contains two lists; the first includes pairs situated south of declination −42°, giving observations of 985 Herschel pairs and of many miscellaneous stars which were measured on the advice of Professor Hussey. The second list is of neglected pairs north of declination −31°. The plan of the work is somewhat similar to that adopted by Van Biesbroeck for the zone contained between +50° and the North Pole (*Bruxelles Publications*, 1913).

T. E. Espin has given measures of 107 miscellaneous double stars of declination 36° to 43° (*M.N.*, 78, 189). Many of these pairs, measured with the 24-inch Calver reflector, are faint and difficult objects of which good observations are valuable.

Rev. T. E. R. Phillips measured 52 pairs with the 8-inch

refractor loaned by the Society (*M.N.*, 78, 477). This list comprises well-known binaries carefully observed on many nights. ξ Bootis and 70 Ophiuchi were each measured on twenty-five nights.

R. Jonckheere (*M.N.*, 78, 479) gives measures of the companion of Sirius obtained on thirteen nights with the 28-inch Greenwich refractor. The mean is given here, together with that obtained by E. E. Barnard at the Yerkes Observatory.

		°	″	
Barnard . .	1918·08	70·6	10·99	8*n*
Jonckheere . .	1918·16	71·0	10·64	13*n*

Procyon was also examined on many nights at Greenwich, but the companion was suspected only once. It should be remembered that for several years the companion of Procyon has not been seen with the large American refractors.

J. Voûte, observing at the Cape Observatory with the 7-inch refractor, contributed observations of 112 miscellaneous double stars of the southern hemisphere (*M.N.*, 78, 683). Also photographic measures of 124 wider pairs obtained with the astrographic refractor reduced to 10 inches aperture. The closest pair observed in this way has a separation of 3″·28.

E. Doolittle (*M.N.*, 78, 376) gives a list of errata to Van Biesbroeck's measures of double stars contained in the *Ann. of the R. Obs. of Belgium*, vol. xiii.

R. T. A. Innes gives measures of 87 southern pairs in *Circ. of the Union Observ.*, No. 41. It is the 7th series of observations obtained with the 9-inch refractor. With this instrument, at Johannesburg, Mr. Innes regularly measures double stars which would ordinarily be the work of an 18-inch refractor.

C. P. Olivier (*A.J.*, No. 733) gives measures of pairs selected chiefly from the lists of Jonckheere and Aitken, there being 45 of the former and 15 of the latter. They were observed with the 26-inch refractor of the Leander McCormick Observatory. This remeasurement of the J stars is especially valuable, since there seems to be a large systematic difference between the distances measured by Olivier and Jonckheere, and it is mentioned that these pairs are very difficult objects even with the 26-inch. Mr. Olivier has the intention of measuring a large number of stars discovered at the Lille Observatory; a most useful undertaking, since the Lille telescope is only a 14-inch refractor.

W. O. Beal (*A.J.*, No. 737) gives observations of 49 miscellaneous stars, each measured on several nights with the 10½-inch refractor of the University of Minnesota.

Professor S. W. Burnham gives measures of 181 wide pairs, made with the view of determining proper motions (*A.J.*, No. 738). The publication of these was entrusted to P. Fox. The measures were made by Burnham in 1911–1913, presumably with the 40-inch Yerkes refractor.

E. D. Roe has given measures of 50 miscellaneous double stars measured mostly with a $6\frac{1}{2}$-inch refractor (*A.J.*, No. 739).

R. Jonckheere has a second series of measures of well-known pairs in *A.J.*, No. 735. The stars were observed on numerous nights over a period of ten years at the observatories of Strasbourg, Lille, and Greenwich. In each case the results are compared with the values calculated from the orbits.

Orbits of Binaries.—G. C. Comstock has made a new investigation of the orbit of Σ 2026 (*A.J.*, No. 725). The periods previously assigned to this binary ranged from 522 to 140 years. The value now found is 215 ± 16 years. This paper contains valuable new differential formulæ for the analytic correction of double star orbits, and may well serve as a model for similar investigations.

G. C. Comstock, using the methods employed in the previous paper, has derived a new orbit of Σ 1879, for which he finds a period of 240 years (*A.J.*, No. 734).

E. Doolittle (*A.J.*, No. 737) has made an elaborate investigation of the motion of Σ 1306, showing that the relative motion cannot be considered rectilinear.

G. van Biesbroeck (*A.J.*, No. 739) points out that the above star has had a pronounced curvature of motion. He also calls attention to Σ 2052 which, after remaining for thirty years with scarcely appreciable motion at a separation of 3″, has lately become a very close pair under 0″·3.

The same author, in *A.J.*, No. 741, gives an orbit of Hough 581. These are the first elements published of this binary, although it has nearly completed one revolution since the discovery in 1895, the period being only 24·44 years. For a first determination, the orbit represents the observations extremely well.

R. G. Aitken has had, for the second time, the unique privilege of determining the orbit of a visual binary star, all the work on which, including the discovery and measures, has been done by himself (*L.O.B.*, No. 317). The star is A 417 = 83 Aquarii, whose duplicity was discovered in 1902, when the separation was only 0″·19. Its maximum value is 0″·24. It is a rapid binary with a period of 23·82 years.

The *Companion to the Observatory*, 1919, contains recent measures of well-known binaries and computed ephemerides for forty-four systems.

The Orbit of Sirius.—The Sirian system received much attention during 1918, the work being carried on almost simultaneously by R. G. Aitken and R. Jonckheere.

Using recent measures made with the 28-inch Greenwich refractor, R. Jonckheere (*M.N.*, 78, 479) gave the results of an investigation on the period of the system. By comparison with the preceding revolution he found 50·10 years, and by corrections indicated by the residuals O − C to the orbits of See, Doberck, and Lohse, the value 50·01 years, thus showing that the periods determined during the last forty years were not so good as the first

value given by Peters in 1851 from the Greenwich transit observations of the bright star.

R. G. Aitken published in *Pub. Ast. Soc. Pac.*, **30**, 194, the results of a similar investigation; by comparison of his measures with the preceding revolution, the period of 50·04 years was deduced.

R. Jonckheere published a new orbit of the system in *M.N.*, **78**, 658. He employed an original method of obtaining graphically with great accuracy connected elements of double star orbits. Doberck's orbit was used for the preliminary elements. The residuals O − C are given for every published value that depends on more than two nights' measures from 1862 to 1918, and there is an ephemeris computed for every year during a complete revolution.

R. G. Aitken (*L.O.B.*, No. 316) published another orbit obtained by the method of differential coefficients, using the residuals of Lohse's orbit. The new residuals are given with the yearly means observed. The paper is followed by a comprehensive study of the radial velocities of Sirius which are shown to agree with the motion deduced from the visual companion.

The orbits found by the two investigators are given here for comparison.

Elements of Sirius.

	Aitken.	Jonckheere.
	y	y
P =	50·04	50·00
T =	1894·13	1894·10
e =	0·595	0·60
a =	7″·57	7″·55
i =	43°·31	43°·4
ω =	214°·31	214°·4
Ω =	42°·71	42°·7
	Angle decreasing.	

These results were independently obtained by very different methods and from two different preliminary orbits. The two determinations are practically identical, and it may be safely concluded that they represent the best results obtainable from the present data (*Pub. Ast. Soc. Pac.*, **30**, 311).

Spectral Types.—In *Pop. Ast.*, **26**, 635, there is a summary of a paper presented by R. G. Aitken to the American Astronomical Society on the spectral types of double stars. It is based on the spectra of 3919 pairs identified in the new Draper Catalogue. The distributions of the visual and spectroscopic binaries are compared. The figures show that while the visual binaries are relatively most numerous in Class G, the spectroscopic pairs have a greater percentage in Class B. R. J.

Stellar Distribution and Motions.

A faint star of exceptionally large proper motion has been found by M. Wolf about 2° from χ Leonis (*Ast. Nach.*, No. 4944). By comparison of plates with 17 years' interval an annual motion of 4″·66 is found. The co-ordinates of the star are α $10^h\ 50^m\ 20^s{\cdot}0$, $\delta + 7^\circ\ 44'\ 37''$ (1875·0), magnitude 13 (presumably photographic). It may be expected that this will prove to be another of the dwarf red stars of very low luminosity of which several examples have been found recently—notably the Barnard star, and the companions to α Centauri, Groombridge 34, and Pi 2^h 123. A. C. D. Crommelin gives a summary of our knowledge of these dwarf stars, with special reference to Barnard's and Innes's stars, in *Scientia*, 1918 November.

A list of 30 parallaxes measured by A. van Maanen with the 60-inch reflector at the Mount Wilson Observatory is published in *Mount Wilson Contributions*, No. 136, and a further list of 25 parallaxes in *Contribution* No. 158. A general review of recent progress in the work of determining parallaxes is given by H. S. Jones, *Observatory*, **41**, 343.

R. Furuhjelm (*Festskrift tillegnad Anders Donner*) makes a further communication on a companion to Capella which he discovered in 1914. The star is of magnitude 10·6, distant 12′ from Capella, and has the same proper motion 44″ per century. The same author gives a list of 63 stars with proper motions exceeding 50″ per century found in the Helsingfors zone (*Öfversigt af Finska Vetens.-Soc. Förhandlingar*, **69**, No. 22).

A long investigation by J. C. Kapteyn of the distances and motions of the B-type stars is published in *Ap. J.*, **47**, pp. 104, 146, 255. The author had previously discussed the stars of this type in galactic longitudes 216° to 360°, and the present paper relates to the stars in longitude 150°–216°. This region includes the local group in Orion associated with the Orion nebula, as well as many other stars more normally distributed. For the nebula group Kapteyn finds by statistical methods a mean parallax $0''{\cdot}0054 \pm 0''{\cdot}0009$; it appears to be a roughly spherical cluster about 40 parsecs in diameter, and its motion agrees in magnitude and direction with that of the outside stars of the same type. From the general discussion it appears that the peculiar motions of the B stars are even smaller than has generally been supposed, the probable component of velocity in any direction being no more than $\pm 1{\cdot}7$ km. per sec. The determination of the distribution of these stars as regards absolute magnitude is complicated by the occurrence of considerable differences between the subdivisions of type B. The maximum frequency is at $-2^m{\cdot}5$ for type B0, $+0^m{\cdot}5$ for B3, $+1^m{\cdot}6$ for B5, $+2^m{\cdot}7$ for B8–B9; it is assumed that the absolute magnitudes are distributed according to an error curve, but for the most part only the brighter half of the curve can be checked by the observational data.

From the parallactic motions of 113 stars of types B8–B9 in

the zone + 24° to + 32° declination, F. W. Dyson and W. G. Thackeray deduce a mean absolute magnitude about zero (*M.N.*, 78, 651). This is not in contradiction with Kapteyn's result above, since the stars in this list are selected by apparent magnitude, and are therefore much brighter than the average.

The B-type star 72 G Columbæ seems to stand quite apart from all other known stars of this class both in luminosity and velocity. J. Voûte (*Ap. J.*, 48, 144) has found for it a parallax $0''{\cdot}069 \pm ''{\cdot}006$, which would give a luminosity very little greater than that of the sun. It has a radial velocity (corrected for solar motion) of 83 km. per sec. The transverse velocity must also be large; but there is some uncertainty, since the Preliminary General Catalogue gives practically zero proper motion in R.A., whereas Voûte from the photographs has found $\mu_\alpha = 0''{\cdot}235$. The discrepancy could easily be cleared up if a rough meridian observation were taken at the present time.

A discussion of star-counts made on the Harvard Map of the Sky has been published by H. Nort (*Recherches Astronomiques, Utrecht*, No. 7). The limiting magnitude is about 11·0. Although the counts do not reach so faint a limit and are not so well standardised as some other recent investigations, they are specially useful for determining irregularities in the distribution of the stars. More than 5000 fields in all parts of the sky were counted, so that the results present a great mass of fairly homogeneous data. The average star-density varies from 10·2 at the galactic pole to 47·8 per square degree on the galactic plane. Outside the Milky Way some conspicuous variations of density with galactic longitude are shown, but there is no indication that we are placed in an eccentric position in the system of eleventh magnitude stars. In the Milky Way the density is very irregular, and maxima in Centaurus and in Cygnus are strongly indicated; but on the whole there is little organic connection between these stars and the brightness of the Milky Way background. This material has been analysed harmonically by H. C. Plummer (*M.N.*, 78, 668). He finds a gradient over the whole sky from a minimum in Lynx to a maximum at the opposite point in Pavo. The harmonics of the second order indicate that the inequalities in distribution in galactic longitude are related to the vertex in such a way that star-streaming will tend to equalise the distribution.

W. J. A. Schouten (*Inaugural Dissertation*, Kurchner, Amsterdam) has discussed the statistical laws of astronomy according to Kapteyn's method. He finds that the classical results obtained by Kapteyn in 1901–2 are very little altered by the use of the most modern data. The paper contains tables of the distribution of stars according to luminosity, as well as a critical discussion of the various methods that have been employed for deducing these statistical results. In a cube of space having a side of 100 parsecs, we may expect to find between 5000 and 6000 stars brighter than the sun, of which 650 will be more than 10 times as bright, 40 more than 100 times as bright, and only 1 more than 1000 times as bright.

From a discussion of the radial velocities of about 1300 stars of late type, G. Strömberg has found striking evidences of orbital motion in the stellar system (*Ap. J.*, **47**, 7). Chiefly by the use of spectroscopic parallaxes, he was able to divide the stars into three groups according to their distance from the sun. In the nearest group the results showed the usual feature of preferential motion in two nearly opposite directions; in the intermediate group the directions of preferential motion were inclined at 143°; and for the most distant group a still more pronounced inclination of 134° was found. The comparison is between the directions of star-streaming in nearly opposite parts of the sky; and the results can be explained if the stars are moving preferentially in circles or spirals in the galactic plane about a centre lying in the direction of galactic longitude 255°.

A review of the state of the problem of the dynamics of the stellar system is given by A. S. Eddington in *Observatory*, **41**, 132.

It now appears to be possible to determine with considerable accuracy the absolute magnitude of any Cepheid variable from a knowledge of its period; consequently, a general idea of the distribution of these stars in space can be obtained. H. Shapley (*Mount Wilson Contributions*, No. 153) has plotted the positions of the Cepheids, and discussed the system which they form. The Cepheids with periods greater than a day all lie close to the galactic plane; on all sides of the sun their distances range up to 4000 parsecs or more, so that they indicate a galactic system of far greater extent than any hitherto discussed. They afford the best determination yet available of the sun's distance north of the true galactic plane—about 60 parsecs.

R. Trümpler has examined the extent of the physical system of the Pleiades (*Pop. Ast.*, **26**, 9). It appears that the cluster has a radius of about 3°, and out of 198 stars within this area brighter than B.D. $9^{m}\cdot0$, about 90 stars actually belong to the group. An investigation of the photo-visual magnitudes of the Pleiades has been made by Harriet M. Parsons (*Ap. J.*, **47**, 38).

B. Lindblad (*Arkiv för Math., Astron. och Fy.*, 13, No. 26) has made extensive determinations of the photographic effective wave-lengths of bright stars by the grating method, with results in good agreement with those of Hertzsprung. The effective wave-length ranges from about 4120 for type B to 4430 for type M. The wave-length is related to the effective temperature (on Wilsing and Scheiner's scale) by the formula

$$\lambda = 4034 + 114 \times \frac{10^4}{T}.$$

The first four hours of the great Draper Catalogue of stellar spectra has been published (*Harvard Annals*, **91**). The work when complete will contain Miss Cannon's classifications of the spectra of 222,000 stars. The material is of the highest importance for studies of the stellar system. A. S. E.

The Distribution of Globular Clusters.

It is well known that the globular clusters are found almost exclusively in one hemisphere of the sky, whose centre lies in the rich star-clouds of Scorpius and Sagittarius. Recently H. Shapley has found methods of determining the distances of these objects, and consequently it has become possible to form a general idea of their distribution in three dimensions.

The primary clue to the distance is the apparent magnitude of the numerous variable stars found in some clusters—a method first used by E. Hertzsprung to estimate the distance of the lesser Magellanic Cloud. The cluster-variables in any one cluster are remarkably uniform in magnitude; for example, those in Messier 3 are of mean magnitude $15^{m}\cdot50$, with an average deviation of no more than $\pm 0^{m}\cdot08$. It seems clear that variables of this type may be accepted as a constant standard of absolute brightness; and when, for example, we find that in ω Centauri the variables appear on the average $1^{m}\cdot93$ brighter than in Messier 3, we may assume that the difference is due entirely to distance. This would make Messier 3 2·4 times more distant than ω Centauri. On this assumption the relative distances of a number of clusters have been found with considerable accuracy. Making use of the results so obtained, it was next discovered that the average absolute magnitude of the 25 brightest stars in a cluster is also a uniform standard—about $1^{m}\cdot3$ brighter than the mean magnitude of the variables; and the new standard can be used for obtaining the distances of other clusters which do not contain many variables. With this additional material it became possible to show that the linear dimensions of the clusters are nearly uniform, so that, where other means fail, a less accurate but still useful approximation to the distance is obtained simply from measurements of the angular diameter on the photographs. Of the 69 clusters whose distribution is discussed by Shapley, the distances of 7 were found from the variables, an additional 21 from the magnitudes of the brightest stars, and the remaining 41 from angular diameters solely.

It is thus possible to map out the distribution of clusters in their proper relative positions in space. Interesting conclusions may be drawn from this map without knowing its absolute scale. But it is possible also to determine the scale, if we know the absolute brightness of our primary standard—the variable stars. This has been deduced from a knowledge of the distances of similar variables in our local stellar system, and the results are to some extent checked by a comparison of the magnitudes of other classes of stars in the globular clusters and our local system.

The question arises how far the 69 objects discussed represent the complete system of the globular clusters. Will there be an artificial limit of distance due to selection by brightness? There is reason to believe that the clusters omitted are not very numer-

ous, and that the selection is quite representative. Increase of instrumental power in the last eighty years has added scarcely any new objects of this kind, though it has been used to settle the character in doubtful cases.

The nearest globular cluster, ω Centauri, is distant 6·5 kiloparsecs; the most remote, N.G.C. 7006, is distant 67 kiloparsecs (a kiloparsec = 1000 parsecs = 3256 light-years). The clusters form a widely diffused system whose centre is distant about 20 kiloparsecs in the galactic plane in the direction of the Scorpius-Sagittarius region already mentioned. The symmetry with respect to the galactic plane is so marked that we must regard the whole system as associated with the galaxy; but this involves a great extension of our ideas as to the dimensions of the galactic system. Our local stellar system, containing probably all the naked-eye stars with millions of fainter stars, is not much more than 1 kiloparsec in diameter, and it lies almost on the circumference of the greater system here outlined. It is for this reason that the globular clusters appear crowded into one hemisphere. The system of clusters is perhaps somewhat ellipsoidal in form; but the spread perpendicular to the galaxy is not markedly less than in other directions. On either side the clusters extend to a distance of more than 20 kiloparsecs from the galactic plane, and indeed there is one outlying member at 50 kiloparsecs distance.

A very remarkable feature of the distribution is a definite cleavage of the system near the equatorial plane. Approaching the galactic plane, we find the clusters more and more concentrated (resembling the oblate distribution of the stars); but then quite suddenly the concentration drops to zero, and we have a small segment entirely free from globular clusters. Perhaps it might be thought that the apparent vacancy is caused by absorbing matter distributed in the galactic plane; from geometrical considerations it is claimed that this explanation will not serve, but the evidence does not seem to be entirely convincing. If the cleavage in the distribution is real, it has important consequences for stellar dynamics. The vacant zone is between 3 and 4 kiloparsecs in width —small in comparison with the magnitude of the cluster system, but vastly greater than the dimensions of our local star-cloud. It is suggested by Shapley that globular clusters can only exist in empty space; and that when they enter the equatorial region populated by stars, they become dissolved into the loose clusters and star-clouds of the Milky Way. From the observed radial velocities of clusters it appears that most of them are travelling towards this region, and that some will enter the prohibited area within a period of the order 100,000,000 years; hence either the present exclusiveness of the regions occupied by stars and by globular clusters is only temporary, and reflects the conditions of their original formation, or we must admit that the clusters break up when they enter the stars' domain. Against the latter view it may be urged that there are not nearly sufficient stars at sufficient distance from the galactic plane to break up a cluster by encounters

in the very limited time available. Our knowledge of the distribution of stars outside our local system is based mainly on Cepheid variables; these appear to be closely concentrated to the galactic plane, and by no means fill the width of the vacant segment.

The dimensions of a globular cluster are somewhat difficult to state, owing to the diffusion of the outer stars. Thus Shapley gives for a typical cluster, Messier 3, a diameter of 150 parsecs, which would make it smaller than but still comparable with our local cluster. But Hertzsprung gives for the same cluster a diameter 5 parsecs, which includes half the total light, making it similar in size to the moving cluster of the Hyades, though much richer in stars. The difference in these estimates is due to the mode of definition of the size of an object with no precise boundary, Hertzsprung referring to the closely packed nucleus and Shapley to the extreme extension. In either case, the system of the clusters resembles other astronomical systems in that the space occupied by the material objects is minute compared with the vast vacant regions. A. S. E.

Stellar Spectroscopy in 1918.

Nebulæ.—The spectra of two variable nebulæ, N.G.C. 2261 and 6729, have been examined photographically at Flagstaff by V. M. Slipher, who finds that the former resembles that of a Nova in having emission lines of hydrogen and enhanced lines, while the latter is identical with that of its nucleus, which is the variable star R Monocerotis (*Lowell Bulletin*, No. 81).

The spectrum of the nebula N.G.C. 7023 is found by V. M. Slipher to be mainly continuous, but the H_β line is bright. The similarity of the light of the nebula to that of the central star suggests the idea that the nebula is shining with the light of the central star (*Pub. A.S.P.*, **30**, 63).

The spiral nebula N.G.C. 1068 is shown by V. M. Slipher's observations to have a composite spectrum of bright and dark lines. The spectra give evidence of rotation and of an enormous radial velocity of + 1120 km./sec. (*Lowell Bulletin*, No. 80).

The spiral nebula N.G.C. 4151 gives a composite spectrum similar to that of N.G.C. 1068. Messrs Campbell and Paddock have photographed it, and find the bright nebular lines in the green region are of considerable width on a continuous background, and that a velocity of + 940 km./sec. is indicated (*Pub. A.S.P.*, **30**, 68).

The rotation and radial velocity of the central part of the Andromeda nebula have been studied by F. G. Pease from a spectrogram taken with an exposure of 79 hours. The velocity of the centre of the nucleus is − 316 km./sec., in good agreement with other earlier measures; and the linear velocity of rotation at a point 2 minutes of arc from the nucleus is 58 km./sec., the slit of the spectrograph being set parallel to the major axis of the nebula (*Proc. Nat. Acad. Wash.*, **4**, 21).

The spectra of the nebulæ N.G.C. 3379 and 1700, small nebulæ

with nearly stellar nuclei, have been photographed by F. G. Pease. The radial velocities deduced are strongly positive, the first-named nebula having a velocity of more than + 800 km./sec. (*Pub. A.S.P.*, 30, 255).

In a paper entitled "The Atomic Weights of the Elements in Nebulæ" (*M.N.*, 78, 358), J. W. Nicholson deduces 1·31 as a more accurate value of the atomic weight of nebulium, derived from considerations of the vibrations of a ring of four electrons round a positive nucleus, a system which when neutral is found to give the vibration periods corresponding to lines in the spectrum of nebulæ. In his earlier work (e.g. *M.N.*, 74, 204) he had deduced as a first approximation a value 1.3, based upon consideration of electrostatic forces only. In the present paper he makes a further investigation, taking account of magnetic and associated mechanical forces, with the result 1·31, which he considers correct to ±0·01.

Novæ.—The most notable event of the year 1918 is the outburst of the brilliant Nova Aquilæ III. A special note is devoted to it and appears on p. 276 above.

Dr. Max Wolf announced that a star in the constellation of Monoceros, of magnitude 8·5, showing the spectrum of a Nova, was photographed at Heidelberg on 1918 February 4. M. Millosewich gave its position as R.A. $7^h\ 22^m\ 48^s$ and Dec. $-6°\ 30'\ 41''$ S. The Harvard observers find that this star must have been fainter than magnitude 10·8 on 1917 December 22, and that on 1918 January 1 it had a magnitude 5·4 (*Harv. Circ.*, No. 209). They also obtained photographs of its spectrum between February 21 and April 6, and found that on February 21, that is, 51 days after the outburst, when its magnitude was 9·9, the nebular lines were prominent. The Mount Wilson observers, Messrs. Adams and Joy, confirmed this feature on February 28 and March 28 (*Pub. A.S.P.*, 30, 162). At Mount Hamilton, G. F. Paddock found the same features on February 25 (*Pub. A.S.P.*, 30, 189; and *L.O.B.*, 9, 170). Comparison with the spectrum of Nova Geminorum II. showed that, though there are differences in details, the star is rightly described as a Nova, and accordingly it takes its name as Nova Monocerotis 1918.

Three more variable stars in the Andromeda nebula have been found by G. W. Ritchey, who describes them as Novæ, apparently without spectroscopic evidence (*Pub. A.S.P.*, 30, 162).

J. C. Duncan announces a ninth variable, which he describes as a Nova, in the Andromeda nebula (*Pub. A.S.P.*, 30, 255).

From photographic observations at Flagstaff, C. O. Lampland gives the magnitudes of recent Novæ between the dates 1917 February and 1918 January. Those relating to 1918 January are as follows:—

		M.	
1918 Jan. 4.	Nova Aurigæ	12·3	*Pub. A.S.P.*, 30, 64.
,, ,, 4.	Nova Geminorum I.	14·9	
,, ,, 3.	Nova Geminorum II.	10·4	

The Harvard observers in their circular No. 204 give a valuable summary of the observed magnitudes of Nova Persei II. from 1902 to the end of 1917.

In continuation of his photographic study of the nebulosity round Nova Persei II., G. W. Ritchey finds further evidence of a ring about 17″ in diameter round the star on 1917 November 15 (*Pub. A.S.P.*, **30**, 163).

Three papers relating to theory in regard to Novæ have been published: the first by Professor Turner, who deals especially with the case of the nebulosity observed round Nova Persei (*M.N.*, **79**, 23), and elaborates earlier ideas outlined in *M.N.*, **72**, 405, the suggestion being that gravitational contraction of a portion of a surrounding nebula leads to the outburst by congestion near the centre; the second by Dr. J. Bosler, who favours the view that a Nova is produced by the passage of a faint or dark star through an obscure nebulous cloud (*Revue Gén. d. Sci.*, 1918 November); the third by W. H. Pickering, who suggests that the falling of a relatively small planetoid into a star would produce a local explosion, developing suddenly an amount of energy which, under appropriate conditions, would account for the observed light changes (*Pop. Ast.*, **26**, 599).

Special Studies.—The Cepheid variable *SU Cassiopeiæ* has been studied spectroscopically by W. S. Adams and H. Shapley (*Ap. J.*, **47**, 46). It has been found to have a velocity curve with eccentricity 0·0, a period $1^{d}\cdot9495$, and a range of spectral type from A9 to F4.

Unmistakable changes in the spectrum of the Wolf-Rayet star γ Argus have been observed by C. D. Perrine (*Ap. J.*, **47**, 52).

The problem of the relation between velocity and distance, or velocity and absolute magnitude, in stellar motions is discussed by C. D. Perrine and by W. S. Adams and G. Strömberg (*Ap. J.*, **47**, 177, 189).

The cause of spectral differences in stars has been studied by C. D. Perrine (*Ap. J.*, **47**, 289), who notes that among 24 pairs of stars in Adams and Joy's list of 500 stars the fainter components of such stars, when near, are of a later spectral type than the primaries. At distances greater than 50–100 parsecs it would appear that the fainter components are of earlier type.

A marked preponderance of outward motions has been found by C. D. Perrine (*Ap. J.*, **48**, 145) among stars of class B, particularly those early in the class, whilst among stars of the classes A, F, G, K, and M no such preponderance is shown.

In a spectrogram of *o Ceti* taken near minimum brightness on 1918 March 2, a number of bright lines, some of which had previously been observed by Stebbins, were photographed by W. S. Adams and A. H. Joy (*Pub. A.S.P.*, **30**, 193), who note that many are lines of iron which are strengthened at low temperatures.

In a note on *Cepheid Variables* (*Proc. Nat. Acad. Wash.*, **4**, 129), W. S. Adams and A. H. Joy call attention to the abnormal strength

of the hydrogen lines in relation to the more general characteristics of the spectrum. They point out that the abnormality is far more strongly marked at maximum brightness than at minimum, and are inclined to regard the variation in spectral type as mainly a variation in the intensity of the hydrogen lines. Other features are referred to.

Infra-red stellar spectra have been photographed by P. W. Merrill (*Sci. Papers, Bur. of Stand., Wash.*, No. 318) at Harvard College Observatory. In some cases the spectra reach wave-length 8700, and in some of the M stars a band due to titanium oxide at λ 7600 has been identified.

The spectra of the planets Jupiter and Saturn have been photographed by L. Becker (*M.N.*, **78**, 77) over a wide range of wave-length.

Classification. — In a summary of a paper on the spectral classification of 3919 visual binary stars (*Pop. Ast.*, **26**, 635), R. G. Aitken points out that, relatively to Pickering's tabulation of all stars as bright as photometric magnitude 6·5 in the Revised Harvard Photometry, the brighter as well as the fainter visual binaries are most numerous amongst stars of class G. On the other hand, among the 605 known spectroscopic binaries, which are nearly all brighter than magnitude 6·0, those of class B are relatively most numerous. The spectral data have been derived from the unpublished new Draper Catalogue.

Radial Velocity.—The radial velocities of 60 southern stars have been determined by J. Lunt (*Ap. J.*, **47**, 201).

The star Boss P.G.C. 1517, a star of class B and magnitude 5·6, has been recorded by J. Voûte as having an unusually large parallax, 0″·069. The radial velocity has been determined by R. E. Wilson, and is found to be unusually large, +102 km./sec., for a star of class B (*Ap. J.*, **48**, 144).

Variable Radial Velocity.—Variable radial velocity has been found in the following stars:—

	M	
66 Eridani	(5·2, Ao)	E. B. Frost (*Ap.J.*, **48**, 260).
64 Piscium	(5·2, F)	Lick Observatory (*Pub.A.S.P.*, **30**, 351).
σ Piscium	(5·5, B9)	,, ,,
κ Arietis	(5·1, A)	,, ,,
f Persei	(4·9, F)	,, ,,
66 Eridani	(5·2, A)	,, ,,
φ 2 Hydræ	(5·1, K)	,, ,,
ξ 53 Urs. Maj.	(4·9, G)	,, ,,
l 45 Herculis	(5·3, Ap)	,, ,,

Twelve stars with variable velocities have been discovered by

J. S. Plaskett within six months of the arrival of the 72-inch mirror at the Victoria Observatory (*Jour. R.A.S. Can.*, 12, 460).

The star 2 ω Leonis was reported in 1907 to have variable velocity by E. B. Frost, who now regards the earlier observation as likely to have been incorrect, an error in setting on a wrong star having probably been made (*Ap. J.*, 45, 258).

Spectroscopic Binary Stars.—Orbits are given for the following stars :—

					P.	*e.*
β Canis Majoris	B1	F. Henroteau	*L.O.B.*,	9, 155	0^d·25	0·04
σ Scorpii	B1	,,	,,	9, 173	0·246	0·11
p Velorum	F2	R. F. Sandford	,,	9, 181	10·211	0·541
δ Columbæ	G5	R. E. Wilson C. M. Huffer	,,	10, 15	870	0·67
A Carinæ	G5	,, ,,	,,	10, 17	195·32	0·0
42 Capricorni	K	J. Lunt	*Ap. J.*,	47, 134	13·25	0·20
32 θ_2 Cygni	G5	J. B. Cannon	,,	47, 194	1170	0·2
α Phœnicis	K	J. Lunt	,,	47, 196	3880	0·32
Boss 46[1]	B3p	W. S. Adams G. Strömberg	,,	47, 329	3·5225	0·94
Boss 1646	A7	A. H. Joy	*Pub.A.S.P.*,	30, 253	2·525	0·00
Boss 1082	G5	J. B. Cannon	*R.A.S. Can.*,	12, 210	123	0·019

The system σ Scorpii, in the above list, is a complex system with interesting features.

The system Boss 46[1] in the above list is of special interest, as the hydrogen and helium lines give velocities varying by 450 km./sec., whilst the calcium lines indicate a variation of only 20 km./sec.

The star Boss 1646 in the above list was recently announced as an eclipsing variable by Schwab, with a period 1^d·2624. A. H. Joy's spectroscopic observations show that this period should be doubled. Both components are seen in the spectra.

The system α Centauri has been studied in a very interesting note by J. Lunt (*Ap. J.*, 48, 182), who has utilised Roberts's element (period 81·18 years, $e = 0·528$, $i = 79° 21'·6$, $a = 17''·71$) for deriving the radial velocities to be expected at various epochs between 1875 and 1956, and has compared the calculated values with observed values obtained since 1904. The difference between the radial velocities of α_1 and α_2 was about 5 km./sec. in 1915 March; it will be zero in 1927, and will become more than 13 km./sec. in 1953.

The radial velocities of ε and γ *Orionis* have been studied by F. Henroteau, without the disclosure of any systematic orbital motions (*L.O.B.*, 9, 178).

Work in the Laboratory.—An interesting investigation of the spectra of calcium, strontium, barium, and magnesium from the standpoint of the lines appearing at each of three stages of temperature in an electric furnace is described by A. S. King (*Ap. J.*, **48**, 13).

Instruments.—The installation of the two large reflectors, one at Mount Wilson, the other near Victoria, B.C., is referred to in a special note, below (G. E. Hale, *Observatory*, 1918, **41**, 429; J. S. Plaskett, *Jour. R.A.S. Can.*, **12**, 399, and *Pub. A.S.P.*, **30**, 267).

The general problem of constant deviation prisms is dealt with by H. S. Uhler (*Ap. J.*, **47**, 65).

Further trials of the method of deriving values of radial velocity from photographs taken with an objective prism and an absorbing screen of neodymium chloride have been made at Harvard College Observatory by T. S. H. Graham (*Jour. R.A.S. Can.*, **12**, 129). H. F. N.

New Telescopes.

During the past year the two largest reflecting telescopes in the world have been completed, viz. the 100-inch telescope of the Mount Wilson Solar Observatory, and the 72-inch telescope of the Dominion of Canada Astrophysical Observatory. That their completion should have been found possible, in spite of difficulties occasioned by the war, will be a matter of satisfaction to all interested in the progress of astronomy.

The chief difficulties in the construction of such large telescopes lie in procuring a sufficiently large and suitable slab of glass, in working it to the correct paraboloidal figure, and in mounting it in such a way that it shall be neither strained nor subject to large or rapid variations of temperature. The design of a satisfactory telescope mounting, driving mechanism, and dome, though requiring engineering skill of a high order, presents no special difficulties.

The thickness of the glass disc should be about one-seventh or one-eighth of its diameter, in order to obtain sufficient rigidity and to reduce the effects of temperature changes. The weight of the discs for telescopes of the size considered must therefore be from 2 to 4 tons. The essential requirement is that the disc should be sufficiently homogeneous to be free from internal strains; it should also be tolerably free from bubbles. These requirements practically necessitate the disc being cast from one melting, an operation of considerable difficulty. The annealing of so large a disc presents, however, even greater difficulties.

The disc used in the Mount Wilson 100-inch telescope was obtained from the French Plate Glass Co. of St. Gobain, France, whose works have been destroyed by the Germans during the war. It was made after repeated preliminary trials on smaller discs, but was at first rejected at Mount Wilson as unsuitable. It was made from more than one melting, and contained layers of bubbles.

The St. Gobain Co. went to much trouble and expense to obtain a better disc, but the only discs which were cast successfully fractured during the annealing. It was therefore decided that work should be commenced on the disc which had been rejected. The work was entrusted to the capable hands of Professor G. W. Ritchey, who followed the methods so lucidly described in his paper "On the Modern Reflecting Telescope and the Making and Testing of Optical Mirrors" (*Smithsonian Contributions*, 34). The figure was tested by the "knife-edge" test, and at its focus with the aid of a 60-inch flat, specially made for the purpose. Elaborate precautions were taken to prevent variations of temperature in the testing-room, and to ensure that the air was absolutely free from dust. The completed mirror has an aperture of nearly 101 inches, a focal length of slightly over 42 feet, a thickness of 12·75 inches at the edge and 11·50 inches at the centre. It weighs over 4 tons. The perfection of its figure can be judged from the fact that outside the central 8-inch zone the largest deviation of the observed from the theoretical focal length for any zone is 0·14 mm., or only one part in 92,000.

The disc for the Dominion Observatory 72-inch reflector was also obtained from the St. Gobain Glass Co., and was shipped from Antwerp only one week before the declaration of war. The optical work was entrusted to the John A. Brashear Co. of Pittsburgh. The disc was found to be remarkably free from bubbles or other defects, but some difficulty was experienced in figuring it. An auxiliary flat of 55 inches diameter had been ordered for use in testing the paraboloidal surface, but the war prevented its delivery by the St. Gobain Co. A delay of one year resulted, whilst fruitless efforts were made to obtain suitable material for the plane in America. This fact will enable one to realise the debt which astronomy owes to the St. Gobain Co. Ultimately it was decided to make zonal tests of the mirror by the Hartmann method, and to make subsidiary tests with a 33-inch plane mirror belonging to the Brashear Co. By an error of judgment, the central hole in the mirror was cut before the figuring: this caused an irregular figure in its neighbourhood and much increased the time taken in figuring. The finished mirror has a diameter of 73 inches, a focal length of 30 feet, and a thickness at the edge of 12 inches. The central hole is $10\frac{1}{8}$ inches in diameter. The weight of the mirror is about 2 tons. The maximum deviation of the observed from the theoretical focal length for any zone is 0·25 mm., so that the figure is not quite so perfect as in the case of the Mount Wilson mirror. The errors, however, are very small, as may be judged from the fact that they are equivalent to a deviation not exceeding one-eighth of a wave in the surface.

The dome and mounting of the 100-inch telescope were designed by Messrs. D. H. Burnham & Co. of Chicago, to particulars provided by Professor Hale, and their construction was carried out by the Fore River Shipbuilding Works. The English type of mounting was decided upon owing to the heavy mass of

the large telescope. The design of the mounting is somewhat similar to that used by Professor Ritchey for the Yerkes 3-foot reflector. The polar axis consists of a massive rectangular framework, 32 feet by 16 feet; the telescope swings in it, supported by two trunnions. The ends of the axis float in mercury tanks, giving a very efficient anti-friction device. The pier proper measures 20 feet by 45 feet at its base, and is 33 feet high. A circular floor 52 feet in diameter extends from the top, being supported on heavy reinforced concrete brackets. From this floor a circular wall rises to the level of the main floor of the steel building. An extension pier was added with a top sloping at an angle equal to the latitude of the observatory to carry out a project of Professor Hale's, according to which the spectrograph is attached to this pier and the telescope is used in coudé form. A larger spectroscope can thus be used than would be possible if it had to be attached to the end of the telescope. The dome has a diameter of about 100 feet, and the height of its top is 105 feet. It has a double roof of sheet iron with an air-space of 2 feet, in order to reduce variations of temperature inside. The shutter is 20 feet wide, and consists of two portions moving on horizontal tracks at the top and bottom. Along the faces of the two sections are cushions to render them air-tight.

The rotation of the dome, the opening and closing of the shutters, and the setting of the telescope in right ascension and declination, are all electrically controlled.

The mechanical parts of the 72-inch reflector and the dome were constructed by Messrs. Warner & Swasey of Cleveland, to particulars provided by Mr. Plaskett. The design follows closely that of the Melbourne 4-foot reflector; the telescope being supported at one end of the declination axis with a counterpoise weight at the other end, whilst the polar axis of 21 feet length and 9½ tons weight is supported on separate bearings at its two ends. A novel feature of the design is the use of ball-bearings of the self-aligning type for the bearings of the polar and declination axes and of the worm-wheel. The use of ball-bearings avoids the necessity of maintaining collimation by plain cylindrical bearings, and of reducing the friction by such devices as mercury flotation. Mr. Plaskett states that a very smooth and accurate motion is obtained with a remarkably small amount of friction. The dome is of steel, 66 feet in diameter, with double walls between which there is continuous circulation of air. The shutters are double, each 8 feet in width, giving a clear aperture of 15 feet, which extends 6 feet beyond the zenith. Canvas wind-screens are provided. As in the case of the 100-inch, all motions of the telescope, dome, shutters, and observing platform are electrically controlled.

The two telescopes proper are very similar to one another. Both have skeleton steel tubes, octagonal in shape and built up in sections. The mirrors are in each case supported in the well-known manner which was designed by Professor Ritchey. Both telescopes

are adapted for use in either the Newtonian or Cassegrain form. The focal lengths of the 100-inch and 72-inch telescopes, when used in the Newtonian form, are respectively 42 feet and 30 feet. In the Cassegrain form the focal lengths obtainable are up to 300 feet and 108 feet respectively. In this form, in the 72-inch reflector, the light passes through the central hole in the mirror and enters the spectroscope which is attached to the lower end of the telescope. The Mount Wilson telescope can be used in addition in the coudé form in which a convex mirror at the upper end of the tube reflects the light on to a diagonal plane mirror placed at the intersection of the polar and declination axes, which in turn reflects it in a constant direction towards the south pole of the heavens. The image remains therefore in a constant position as the telescope moves. In this form the telescope will be used for high-dispersion photography of stellar spectra with a long-focus spectrograph.

Regular observations have not yet been commenced with the 100-inch telescope. Some trouble was experienced at first owing to change of figure of the mirror due to slight temperature variations, although an elaborate water-cooling arrangement surrounded the mirror to prevent such disturbing effects. These difficulties have now been overcome, and it is understood that the preliminary observations have proved very successful.

Difficulties were also experienced at first with the 72-inch telescope owing to temperature changes. No cooling arrangement had been provided, as it had been considered that the temperature variations inside the dome would be small. To minimise such effects, therefore, the lower end of the tube has been permanently encased with quilted end-covers. The performance of the mirror is now satisfactory. With a single-prism spectrograph, giving a linear dispersion at $H\gamma$ of about 35 A. per mm., excellent spectra of stars of $7^{m}\cdot0$ can be obtained in about 25 minutes. Nearly 400 spectra had been obtained by 1918 July, after only two months' observing. By the end of October last 750 spectra had been obtained. These are obtained as part of a regular radial velocity programme. Twelve spectroscopic binaries have already been discovered, details of which are given by Mr. Plaskett in *Jour. R.A.S. Canada*, 12, 460, 1918. At Victoria the difficulty will evidently be to prevent measurements and reduction from lagging too far behind the observing. H. S. J.

List of Public Institutions and of Persons who have contributed to the Library, etc., since the last Anniversary.

His Majesty's Government in India.
The Lords Commissioners of the Admiralty.
The Crown Agents for the Colonies.
British Association for the Advancement of Science.
British Astronomical Association.
British Horological Institute.
Conjoint Board of Scientific Societies.
Institution of Civil Engineers.
Institution of Electrical Engineers.
London Mathematical Society.
London, University College.
Meteorological Office.
National Physical Laboratory.
Physical Society of London.
Royal Institution of Great Britain.
Royal Observatory, Greenwich.
Royal Photographic Society of Great Britain.
Royal Society of London.
Belfast, Natural History and Philosophical Society.
Bradford, Libraries, Art Gallery and Museums Committee.
Cambridge Philosophical Society.
Cambridge, Solar Physics Observatory.
Cambridge University Press.
Chaldæan Society.
Chatham, Royal Engineers' Institute.
Dublin, Royal Irish Academy.
Dublin, Royal Society.
Edinburgh Royal Observatory.
Edinburgh, Royal Society.
Leeds Astronomical Society.
Manchester Astronomical Society.
Manchester Literary and Philosophical Society.
Oxford, Radcliffe Observatory.
Oxford, University Observatory.
Stonyhurst College Observatory.
Allegheny Observatory.
American Astronomical Society.
Arcetri, Reale Osservatorio.
Association Géodésique Internationale.

Barcelona, Sociedad Astronomica.
Basel, Naturforschende Gesellschaft.
Batavia, Royal Magnetical and Meteorological Observatory.
Besançon, Observatoire.
Calcutta, Astronomical Society of India.
Canada, Royal Society.
Cape Town, Royal Society of South Africa.
Cape Town, South African Association for the Advancement of Science.
Catania, Società degli Spettroscopisti Italiani.
Chicago, Society for Practical Astronomy.
Christiania, Norske Meteorologiske Institut.
Copenhagen, K. Danske Vidensk. Selskab.
Copenhagen, Observatorium.
Geneva, Société de Physique et d'Histoire Naturelle.
Harvard College Astronomical Observatory.
Helsingfors, Finska Vetenskaps Societet.
Helsingfors, Observatorium.
Hyderabad, Nizamiah Observatory.
India, United Service Institution.
Japan, Astronomical Society.
Johannesburg, Union Observatory.
Kodaikánal and Madras Observatories.
La Plata, Observatorio Astronomico.
Lick Observatory.
Lisbon, Academia das Sciéncias.
Lisbon, Observatorio Astronomico.
Lowell Observatory.
Lund, Astronomiska Observatorium.
Madrid, Observatorio Astronómico.
Madrid, Real Academia de Ciencias.
Marseille, Observatoire.
Mauritius, Royal Alfred Observatory.
Melbourne Observatory.
Montpellier, Académie des Sciences et Lettres.
Mount Wilson, Solar Observatory.
Netherlands Geodetic Commission.
Neuchatel, Observatoire Cantonal.
New Zealand Department of Lands and Survey.
Northfield, Minn., Goodsell Observatory.
Paris, Académie des Sciences.
Paris, Bureau des Longitudes.
Paris, Ministère de l'Instruction Publique.
Paris, Société Astronomique de France.
Paris, Société Mathématique de France.
Paris, Société Philomathique.
Perth, Western Australian Astronomical Society.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Rio de Janeiro, Observatorio.

Rome, Reale Accademia dei Lincei.
Rome, Società Italiana delle Scienze.
San Francisco, Astronomical Society of the Pacific.
Stockholm, Kungliga Svenska Vetensk. Akademie.
Stockholm, Observatorium.
Swarthmore College, Penn., Sproul Observatory.
Tacubaya, Observatorio Astronómico Nacional.
Tokyo, Observatoire Astronomique.
Toronto, Royal Astronomical Society of Canada.
Toronto, Royal Canadian Institute.
Tortosa, Observatorio del Ebro.
Travancore Observatory.
Turin, Società Urania.
Utrecht, Observatoire Astronomique.
Washington, Carnegie Institution.
Washington, National Academy of Sciences.
Washington, Navy Department.
Washington, Smithsonian Institution.
Washington, United States Coast and Geodetic Survey.
Washington, United States Naval Observatory.
Wellington, Hector Observatory.
Yerkes Observatory.
Zikawei, Observatoire.
Editors of the "American Journal of Mathematics."
Editors of the "American Journal of Science."
Editor of the "Astronomical Journal."
Editor of the "Astronomische Nachrichten."
Editors of the "Astrophysical Journal."
Editors of the "Bulletin des Sciences Mathématiques."
Editor of the "English Mechanic."
Editor of "Nature."
Editors of "The Observatory."
Editors of "Popular Astronomy."
Editors of "Terrestrial Magnetism."

Prof. H. Andoyer.
M. G. Bigourdan.
H. J. Brooks, Esq.
Prof. W. W. Campbell.
M. Camille Flammarion.
M. Raoul Gautier.
Prof. G. E. Hale.
Sir A. F. R. De Horsey.
S. S. Hough, Esq.
Capt. Alex. Inglis.
George R. Kaye, Esq.
Joseph Lunt, Esq.
M. M. Maggini.
Col. E. E. Markwick.
Eugene Miller, Esq.
Prof. W. H. Pickering.
Messrs. Putnam's Sons.
J. H. Reynolds, Esq.
W. J. A. Schouten, Esq.
Shingo Shinjo, Esq.
Dr. Ludwik Silberstein.
Prof. Elis Strömgren.
Messrs. W. Wesley & Son.
Dr. J. Woltger.
Issei Yamamoto, Esq.
M. H. J. Zwiers.

ADDRESS

Delivered by the President, Major P. A. MacMahon, on the award of the Gold Medal of the Society to M. Guillaume Bigourdan.

This year the Gold Medal of the Society has been awarded by the Council to M. Guillaume Bigourdan, Assoc. R.A.S., for his observations of Nebulæ carried on for about twenty-five years.

It seems to me to be appropriate that a medal bestowed in recognition of work entirely connected with nebulæ should emanate from the principal body which is devoted to astronomy in the British Empire. Prior to 1609 the discovery of objects which appeared to be differentiated from ordinary stars, situated elsewhere than in the Milky Way, by a more or less cloudy aspect, depended entirely upon naked-eye observation, and perhaps a mere dozen were so recorded. These included the nebulæ in Orion and Andromeda. With the advent of the telescope it was soon realised that the number of these bodies was large, and as optical means improved we find that on the one hand the increase was continuous, on the other, objects which had previously appeared to be nebulous were found to be in fact simply assemblages of small stars. It was even doubted whether, given sufficient optical power, there would prove to be any nebulæ properly so called at all. During the latter half of the eighteenth century, if we except principally Lacaille and Messier, the discovery, discussion, and cataloguing of nebulæ became, through the labours of the elder Herschel, a particularly British pursuit. I propose to say a few words about his work and that of some others in order to make good my point, and to ascertain how the science stood at the time that the Medallist undertook to carry through a definite series of observations.

Herschel employed a Newtonian telescope 20 feet long and 18·7 inches aperture, magnifying 157 times, and having a field of 15 minutes. In 1786, 1789, and 1802 he published, in communications to the Royal Society, three catalogues containing 2500 new nebulæ and clusters of stars found in the Northern hemisphere. He did not give the absolute co-ordinates of the objects, but referred them in right ascension and polar distance to neighbouring bright stars which were not near enough to be seen in the field with them. He added to the second and third catalogues remarks on the construction of the heavens. In these he attempted to divide all objects into twelve classes, of which the last six contained exclusively those of a nebulous nature.

In 1811 he brought forward his well-known hypothesis of the transformation of nebulæ into stars, the first serious discussion of the kind that had been given by any astronomer. His son,

J. Herschel, continued the observations with an 18·25-inch reflector having a length of 20 feet, and as the result of eight years' (1825–33) work at Slough he gave forth a catalogue of 2307 objects, of which 525 were recorded for the first time. Taking his telescope to the Cape of Good Hope, he then explored the Southern hemisphere. He published his results in his most important contribution to astronomy. It contains a catalogue of 1708 nebulæ arranged in order of right ascension, and with his former catalogue may be taken to include all the nebulæ in both hemispheres that were visible in the 18·25-inch reflector. The number of nebular and stellar aggregations classed with them had now grown to 4500.

In the meantime the subject had engrossed the attention of Lord Rosse at Birr Castle. In 1827 he was interested in the construction of large mirrors for reflectors, and under his directions 3 feet and 6 feet instruments were successively built. The latter had a length of 55 feet, and was much the most powerful telescope that had ever been employed. Both reflectors were almost entirely devoted to the study of nebulæ, so that there is little wonder that new knowledge rapidly accrued. Results of the observations appeared in *Philosophical Transactions R.S.* for the years 1844, 1850, and 1861. No organised search for new nebulæ appears to have been made, but the most splendid work was accomplished in definitely ascertaining the structural forms of known objects. Thus many were resolved into separate stars for the first time; several were found to have forms which were quite different from those revealed by telescopes of less power; spiral forms were for the first time established—others that were regarded by the Herschels as being of uniform brightness and named planetary nebulæ were in some cases now found to be distinctly annular with a dark central region. The major portion of the observations did not appear until they were edited by J. L. E. Dreyer in 1878, accompanied by numerous lithographs and diagrams. This astronomer had been an assistant at Birr Castle from 1874, and was destined to make other important contributions to the subject.

In 1877 he published "A Supplement to Sir John Herschel's 'General Catalogue of Nebulæ and Clusters of Stars'" (*R.I.A. Trans.*, 1877). This Supplement contained 1172 objects.

He followed this with "A New General Catalogue of Nebulæ and Clusters of Stars," being the catalogue of the late Sir J. Herschel, Bart., revised, corrected, and enlarged (*Mem. R.A.S.*, 49, 1888). This contained 7840 objects.

Two index-catalogues of nebulæ found between 1888 and 1907 came from the same hands (*Mem. R.A.S.*, 51, 59, 1895 and 1907). These contained 1529 and 3857 objects respectively.

Finally, he has given to us "Corrections to the New General Catalogue resulting from the revision of Sir W. Herschel's three catalogues of Nebulæ."

In this rapid *aperçu* of the work of British astronomers during more than a century on the subject which the Medallist has

chosen for his life's work, mention has not yet been made of the good work done during this period by astronomers of other nationalities; but it is incontestable that the labours specified must, in any history of nebulæ, be placed in the most prominent positions. To the above it is interesting to add that the first study of the spectrum of a nebula was made by W. Huggins in 1864. He it was who first saw the bright green line which no one had ever seen in the spectrum of a star, and who proved definitely the existence of nebulous matter properly so called.

One of the pioneers in astronomical photography was A. A. Common, who in 1882 obtained a fine negative of the great nebula in Orion.

I therefore, in view of the above, feel justified in remarking on the appropriateness of the award of this particular medal by the Royal Astronomical Society.

Up to the middle of last century it was generally believed that nebulæ could only be usefully observed with large telescopes. But in 1853 a French astronomer, Laugier, showed what could be done even with very small instruments, by publishing the positions of 53 bright nebulæ obtained from micrometer measures with a refractor of only 0·097-m. aperture. The lead thus given was followed by d'Arrest, Schönfeld, Rumker (all of whom used annular micrometers), by Schultz, Vogel, Engelhardt, and Dreyer using filar micrometers. The latter were also used by Winnecke, Kobold, and Wirtz, whose observations with the 18-inch refractor at Strasbourg were about contemporary with M. Bigourdan's, and embrace 1554 objects.

Of work on nebulæ carried out without a micrometer, the observations of d'Arrest with the 11-inch refractor at Copenhagen stand in the first rank. They give places and descriptions of 1942 nebulæ of which nearly 400 were new. Search for new nebulæ was carried out by Marth, who found 600 new objects with Lassell's 4-foot reflector at Malta; by Stephan, who found and observed micrometrically about 500 new nebulæ with a Foucault telescope of 0·80-m. aperture; and more recently by Javelle, who found and measured nearly 1500 new nebulæ with the 30-inch refractor at Nice. While the positions given by these observers were very accurate, only very rough places were given by Swift and Ormond Stone for the new nebulæ found by them, and these objects were badly in need of being reobserved.

M. Bigourdan thus had before him in 1884 a mass of catalogues and separate memoirs concerning nebulæ. Many of the observations that had been recorded had no pretensions to precision in measurement. Some that were precise according to views held in regard to precision at the time they were made could not be regarded as such at the present day. He gives a list of observations which may be regarded as being more or less precise. It commences with Lacaille and Messier, but he gives his opinion that the requisite precision was not reached by any observer prior to the second half of the nineteenth century. The list contains

about 150 names. He also found that as the observations had been made by telescopes involving a wide range of optical power, it was difficult to compare the objects observed or even broadly to classify them.

Further, many of the nebulæ had not been reobserved for a great many years, and then only with instruments of small power. He therefore resolved in 1884 to observe the whole of the nebulæ visible in the latitude of Paris with the equatorial of 0·31-m. aperture installed in the Paris observatory.

He has given a full description of this instrument with drawings to scale. It had been erected more than twenty-five years before by W. Eichens to the designs of Villarceau, and had made its debut in an observation of Donati's comet in 1858. The instrument was very steady, and kept its adjustment well. This and other features had been thoroughly tested in 1882, when preparing for observations for the parallax of Victoria. The original Secretan objective was replaced by one by Martin having a focal length of 5·25 m. and an effective diameter of 0·305 m. Two platinum wire micrometers requiring no illumination, that had been well studied, were used throughout the work. The eyepiece mostly used had a magnifying power 159 and a 16-minute field, and could be altered by an intermediate lens so as to give higher magnifications as high as 953.

In preparation for the work the recorded nebulæ concerned were divided into groups corresponding to definite regions of the heavens, not as a rule exceeding a square of 4° side; he then made a map for each region graduated in right ascension and declination upon which he entered the nebulæ from their co-ordinates for the epoch 1860, and also a sufficient number of stars brought to the same epoch, taken from the Bonn Durchmusterung. A glance then showed the best comparison stars. The method of observation consisted in referring the nebulæ to a sufficiently near star in the same field of view and then measuring the relative position-angle and distance, thus following the practice of experienced observers such as O. Struve, the Birr Castle astronomers, and Messrs. Winnecke, Kobold, and Wirtz at Strasbourg.

The Medallist's labours of observation terminated after twenty-five years in 1909, when 6380 nebulæ had been duly recorded. The general accuracy of the measures is comparable to that of the best micrometric measures of nebulæ of Schultz, Vogel, and Engelhardt.

This work was originally scattered through seventeen volumes of the *Annales de l'observatoire de Paris*, as the observations have generally been published one hour of R.A. at a time, beginning with the volume for 1884, which contains a most interesting introduction, and ending with the volume for 1907 (cf. *C.R.*, 156. 499, 1913 Feb. 17). The work has now been republished in five volumes (*Observations de Nébuleuses et d'Amas Stellaires*), and has been presented to the Society by the author.

These observations form a perfect lexicon of nebulæ, as much information is given concerning practically all the objects of the

N.G.C., and many others which are visible from Paris. The number observed, about 7000 (including about 550 new ones), is far in excess of the number observed elsewhere with or without a micrometer. Sir John Herschel has about 4000 to his credit in both hemispheres, and d'Arrest about 2000—they both received the gold medal of the Royal Astronomical Society,—while the greatest number observed outside Paris with the micrometer is 1554 at Strasbourg.

The results are most attractively presented.

On opening the large quarto volume we find eighteen columns spread across the two pages before us.

Col. 1 contains the N.G.C. number of the objects, these letters denoting Dreyer's New General Catalogue (including supplements) referred to above. M. Bigourdan bears testimony to the great services this fine catalogue has rendered to him. This number is followed by the G.C. number, meaning the number in J. Herschel's catalogue.

Col. 2 indicates the discoverer of the nebulæ and the names of the observers who have determined its position with precision. In general the sources of approximate positions and of descriptions are not given, but the reader is referred frequently to the *Siderum Nebulosorum Observationes Havnienses* of d'Arrest and the volumes enshrining the observations of Birr Castle.

Col. 3 gives the date of the observation, the hour-angle of the nebula, and the magnification employed.

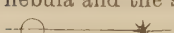
Col. 4 gives the brightness of the object measured in magnitudes, as in the case of stars. These mostly lie between 13·2 and 13·5, the latter magnitude denoting objects at the extreme limit of visibility for the eye of M. Bigourdan and the Paris equatorial. The column also gives the weather conditions and other circumstances affecting the visibility.

Col. 5 gives the readings of the position circle. The operation by which this reading is obtained is given in col. 8. See also col. 9.

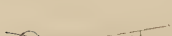
Col. 6 gives the readings of the screw micrometer.

Col. 7 gives the number of the measurements from which the entries in cols. 5 and 6 are deduced.

Col. 8. Symbols are given here which indicate the manner in which the differences of position-angle and distance between the nebula and the star were arrived at.


indicates that the wire was brought into coincidence with both nebula and star (or comparison nebula).

that the wire was brought into coincidence with the star, and successively each edge of the wire into coincidence with the nebula.


that the wire was brought into coincidence with the nebula, and successively each edge of the wire into coincidence with the star.

both the nebula and the star brought into coincidence with each edge of the wire.

In exceptional cases the reader is referred to col. 18.

Cols. 9 and 10 give the position-angle and distance as derived from cols. 5 and 6 by the corrections for zero.

Col. 11 gives the corrections for refraction to be added to cols. 9 and 10.

Col. 12 gives—

$$\frac{\text{apparent difference of right ascension}}{\text{secant mean of the declinations of nebula and star}}$$

derived directly from the position-angle and distance after correction for refraction.

Col. 13 gives the value of the apparent difference of right ascension obtained by multiplying the number in col. 12 by the secant specified in the denominator.

Col. 14 gives the value of the apparent difference of declination.

Col. 15 gives the values of the numbers in cols. 13 and 14 for the epoch 1900·0.

Col. 16 gives the right ascension and declination of the comparison star.

Col. 17 gives the magnitude of the comparison star, quoting the authority and giving the reference.

Col. 18 is devoted to descriptions and remarks. These were as a rule dictated by M. Bigourdan when his eye was at the telescope. Subsequent additions are given in italics.

The general shape is noted as "round," "fairly round," "elliptic," "elongated," "irregular," "with extensions," "of a form that cannot be estimated," "triangular," etc.

The general aspect as being "nebulous," "diffuse," "planetary," "granular," "a cluster," "stellar," etc.

In the case of nebulosity the size, usually the diameter, is given in seconds of arc.

The relative brightness of different parts is given.

Detail is given as to "a nucleus," and the extent to which it appears to be stellar; as to "condensation" and "bright points," which may possibly be stars; as to colour in some cases. In one case at least the object is described as resembling a planet in one of its phases.

In the case of a cluster, the size, shape, and closeness of the constituents are remarked upon—in some cases the stars seem to be superposed.

The stellar aspect of the whole field of view is generally noted.

The causes which militate against precision of measurements are given—frequently absence of a definite nucleus or its too great proximity to or distance from the comparison star, or moonlight are the reasons.

In not a few instances a nebula, as recorded in a previous catalogue or memoir, was not seen. In such a case the part of the heavens in which a search was made is duly noted.

In chapter vi. of the introduction M. Bigourdan gives a short account of the application of photography to the discovery of

nebulæ. During the last twenty or thirty years and quite recently a great many have been found by the Harvard astronomers at Arequipa, using the Bruce telescope of 24-inch aperture—also by J. E. Keeler with the Crossley 36-inch reflector of the Lick Observatory. From the number of nebulous objects, many of them of spiral form, which appeared upon its plates after exposure to a particular part of the heavens for four hours, the latter estimated nearly twenty years ago that there must be at least 120,000 in the entire sky. Nearly 4000 have been discovered by Max Wolf at Heidelberg with the Bruce telescope provided with a doublet having an aperture of $0^m{\cdot}40$ and a focal distance of $2^m{\cdot}32$. Comparing the results with those given in Dreyer's New General Catalogue, it appears that these plates show for the same regions of the sky from ten to fifty times as many objects as had been previously catalogued.

Perrine, from later results at the Lick Observatory, raises Keeler's estimate from 120,000 to from 500,000 to a million. Max Wolf, comparing his first five lists with the catalogues of Dreyer, considered that 260,000 new nebulæ had yet to be placed to the credit of the Bruce telescope which was at his disposal.

M. Bigourdan states that he regards the volumes as a bibliography of memoirs relating to the discovery and measurement of nebulæ. In the text he gives information concerning our knowledge of their constitution, and of the rôle that they probably play in the formation of the universe. Measurements of the utmost precision are of commanding importance, for they are able to extend our knowledge of the absolute distances of the stars. Exactness in determination of position throws light upon their proper motions. If we suppose the parallax of a nebula to be $0''{\cdot}01$, the movements of the solar system in a century should produce a parallactic displacement of six seconds. As a result it is seen that if in the mean the observed displacements are but one-tenth of $6''$, we gain the information that the parallax of a nebula is of the order $0''{\cdot}001$. We can also extend our knowledge of the true movement of the solar system in space. If we suppose the sun to be one of innumerable stars which compose the galaxy, its displacement, deduced from the proper motions of the stars, is merely a relative movement in the galaxy; and the displacement of the galaxy can only be considered with reference to the most remote nebulæ.

Most of the theories regarding the origin and growth of the solar system, or generally of a stellar system, proceed from an extended nebulous mass animated by rotation or vortex motions; this mass is supposed to be of great tenuity and to become gradually condensed with the efflux of time. The discovery of spiral nebulæ, the number of which is being continually increased, adds to the probability of such theories. At the present time we do not know much about the relations which exist between nebulous matter and stars, but we have certain positive indications due to spectroscopic research. Thus Huggins, directing the slit of his

spectroscope toward the star lying near the centre of the great nebula in Orion, found bright lines prolonging the lines of the nebula. He concluded that there was a physical connection between the star and the nebula, and that they were at approximately the same distance. Similar conclusions were derived by the brothers Henry from photographs of the Pleiades. M. Bigourdan considers that the evidence is as yet too scanty to throw much light upon this matter. We require to know more about the distances of the nebulæ before we can conjecture their rôle in the universe, and as their generally diffuse aspect makes the determination of parallax difficult and uncertain, it is little to be wondered at that the rare attempts have resulted in insensible parallaxes. The two overriding desiderata from another point of view appeared to be (1) the precise shapes of a number of nebulæ properly so called in space, (2) observations of changes that are taking place in them. As regards the former, dating from the observations at Birr Castle, to which reference has been made, certain facts have been collected; as regards the latter, we appear to have no certain information at all.

Everywhere we see a contact between the finite and the infinite and a contest between them; between the finite powers of the instruments and the infinite distances of the celestial regions.

M. Bigourdan has practically been at the telescope during every fine night for nearly a quarter of a century, and it might be thought that he would have had little opportunity for other scientific work. But this has not proved to be the case. He has found time to engage in eclipse work on several occasions. He has displayed interest in seismological developments, and as recently as the year before the war, 1913, he was busy with the application of wireless telegraphy to the fixing of the difference of longitude between Paris and Washington D.C. In 1901 he produced a book upon the metric system of weights and measures which begins with a historical account of its establishment in France and its gradual penetration into many other countries, and goes on to describe in great detail the operations that were undertaken by men of science to determine precisely the metre and the kilogramme. These included a redetermination of the length of the seconds pendulum and the measurement of the arc of the meridian between Dunkerque and Barcelona. The book may be said to contain an account of the progress in exact measurement of length and weight during about a century, which can be found in no other work. It is based on the original documents in Paris, and will always be regarded by the metrologist as the principal classic of his subject. There were a few comparatively long periods of suspension of the Paris observations. One of these is responsible for making M. Bigourdan a particularly suitable recipient of a medal from this Society. For nearly a year, early in the present century, he resided at Greenwich for the purpose of collaborating with our Astronomer Royal in a new study of

the difference of longitude between London and Paris. During this period he became well known to a large number of British astronomers and to many in other branches of science. He made lasting friendships with us, and is probably well known personally at the present day to the large majority of those who habitually attend the meetings of the Society. This happy interlude in the observations leads me to remark that it does not constitute the only reason why we are delighted to show him honour. He is a citizen of our great ally with whom we have been latterly marching towards one of the greatest military achievements in history. A new era of good feeling between the two nations has begun, and the men of science may be trusted to make the most of it; for scientific sympathy is an edifice which is based upon the solid rock of scientific research and co-operation. It may be noticed that when relations become strained between two countries it is the men of science who hold together longest, and in the contrary case the bonds between them are the first to become strengthened when relations show signs of becoming cordial.

I regret that M. Bigourdan has found it impossible to be with us this afternoon to receive the medal in person, but with the usual courtesy, a member of the French Embassy is here to take possession of it on his behalf.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected: —

President.

Alfred Fowler, Esq., F.R.S., Professor of Astrophysics, Imperial College of Science and Technology, South Kensington.

Vice-Presidents.

Sir F. W. Dyson, M.A., LL.D., F.R.S., Astronomer Royal.
J. W. L. Glaisher, Esq., Sc.D., F.R.S.
Major P. A. MacMahon, D.Sc., Sc.D., LL.D., F.R.S.
H. F. Newall, Esq., M.A., D.Sc., F.R.S., Professor of Astrophysics, Cambridge.

Treasurer.

E. B. Knobel, Esq.

Secretaries.

A. C. D. Crommelin, Esq., B.A., D.Sc.
Rev. T. E. R. Phillips, M.A.

Foreign Secretary.

H. H. Turner, Esq., D.Sc., D.C.L., F.R.S., Savilian Professor of Astronomy, Oxford.

Council.

A. E. Conrady, Esq., Professor of Optical Design, Imperial College, South Kensington.
J. L. E. Dreyer, Esq., Ph.D.
A. S. Eddington, Esq., M.A., M.Sc., F.R.S., Plumian Professor of Astronomy, Cambridge.
Brig.-Gen. E. H. Hills, C.M.G., D.Sc., F.R.S.
J. H. Jeans, Esq., M.A., F.R.S.
Harold Jeffreys, Esq., M.A., D.Sc.
H. S. Jones, Esq., M.A., B.Sc.
Lieut.-Col. H. G. Lyons, R.E., F.R.S.
E. W. Maunder, Esq.
W. H. Maw, Esq., LL.D.
J. W. Nicholson, Esq., M.A., D.Sc., F.R.S., Professor of Mathematics, King's College, University of London.
Lieut.-Col. F. J. M. Stratton, M.A., R.E., D.S.O.